# 2003 Crop Residue Disposal Smoke Management Program

## DEQ Technical Review of Boundary County and Rathdrum Prairie Airsheds

FINAL REPORT

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## Program Overview

This technical report will provide information on the air quality and meteorological conditions that occurred during the 2003 agricultural field burning season. These environmental factors were used by the Crop Residue Disposal Smoke Management Program (SMP) to make daily burn/no-burn decisions and to evaluate continuation of burns during a burn day. The report is organized to provide an overview of weather and air quality for the northern Idaho counties with an emphasis on the agricultural burning activity that occurs in Kootenai and Boundary counties. This report will include a section for each of these areas to discuss the air quality data and other pertinent data that is available in each airshed to support the SMP. This report will not discuss the agricultural burning that occurs within the exterior boundaries of the Coeur d'Alene Indian Reservation.

## Seasonal Weather

Just like farming, the seasonal weather patterns in north Idaho substantially influence the crop residue smoke management program. During the field burning season, weather can vary from hot and dry to unseasonably cool and wet. According to climate data maintained by the National Weather Service site in Spokane (Table 1), the average monthly temperatures for August and September in 2003 were about normal when compared to the thirty-year average for each month. The total precipitation for August was lower than normal while the September precipitation was normal. In August, measurable amounts of precipitation were recorded on four days and trace amounts of rain were recorded on two days. The previous month of July was dry with only 0.01 inch of rain reported for the entire month. An evaluation of the heating and cooling degree-days seems to indicate that August and September were normal per the historical record.

Table 1. Climate Data from Spokane NWS Site - 2003

| Parameter | August | September |
|---|---|---|
| Avg. Monthly Temperature, 2003 | 68.7 F | 60.9 F |
| Historical Mean Monthly Temp | 69.6 F | 60.8 F |
| Total Monthly Precipitation, 2003 | 0.35 in | 0.93 in |
| Historical Avg Monthly Precip | 0.79 in | 0.86 in |
| Heating Degree Day (base 65°F) | 5 | 166 |
| Historical Avg HDD (base 65°F) | 35 | 165 |
| Cooling Degree Day (base 65°F) | 127 | 50 |
| Historical Avg CDD (base 65°F) | 177 | 39 |

Note: Heating degree-day (HDD) is a unit of measure to track heating requirements or fuel consumption. HDD is calculated by substracting the average daily temperature from 65°F when the average temperature is less than the base. Cooling degree-day (CDD) is a unit of measure to track the amount of energy needed to cool the air. CDD is calculated by subtracting the base temperature (65°F) from the average daily temperature when it is greater than the base.

Additional climate trends are available from the Coeur d'Alene Airport in Kootenai County, and for two locations in Boundary County at Porthill and Bonners Ferry. Temperature and precipitation data for August and September are presented in the following table. The climate data for these sites were obtained from the Western Regional Climate Center website at www.wrcc.dri.edu . The historical averages were based on the thirty-year trend reported in the 1971-2000 Monthly Normals.

Table 2. Temperature and Precipitation Data for Kootenai and Boundary Counties

| Parameter | | Coeur d'Alene Airport Kootenai County | Bonners Ferry Boundary County | Porthill Boundary County |
|---|---|---|---|---|
| **August** | | **August** | | |
| Mean Temp (F) | 2003 | 71.40 | 69.9 | 69.53 |
| | 30 yr Monthly Norm | 69.2 | 66.7 | 65.4 |
| Mean Precip (inches) | 2003 | 0.58 | 0.45 | 0.33 |
| | 30 yr Monthly Norm | 1.16 | 1.07 | 1.21 |
| **September** | | **September** | | |
| Mean Temp (F) | 2003 | 61.75 | 59.6 | 59.57 |
| | 30 yr Monthly Norm | 60.3 | 57.1 | 55.8 |
| Mean Precip (inches) | 2003 | 1.58 | 0.71 | 1.06 |
| | 30 yr Monthly Norm | 1.12 | 1.16 | 1.24 |

The data in Table 2 suggest that the mean temperatures for August and September were slightly higher than the 30-year average at these locations. The data also indicates that rainfall during August was lower than normal at all three sites but was closer to normal during September.

Based on the climate data and field observations, the 2003 burn season had typical weather for the region with no weather anomalies. The slightly higher average temperatures and lower rainfall in August provided good conditions for keeping residue dry and ready for burning. Residue dryness was probably also affected by other factors not recorded in the climate record such as relative humidity or local dew formation.

## Air Quality Standards

In north Idaho, air quality monitoring for the National Ambient Air Quality Standards (NAAQS) is focused on particulate matter (PM). Particulate matter has two size based standards, $PM_{2.5}$ and $PM_{10}$. $PM_{2.5}$ is particulate matter less than or equal to 2.5 microns in aerodynamic diameter and is usually associated with combustion sources. $PM_{10}$ is particulate matter less than or equal to 10 microns in aerodynamic diameter. $PM_{10}$ measurements include the $PM_{2.5}$ fraction in addition to larger particles that are generally associated with mechanical processes such as mineral processing and geologic sources such as wind-blown dust. $PM_{2.5}$ is a good environmental indicator for monitoring the impact of all sources of smoke including agricultural burning.

Air quality was measured by reference methods for $PM_{2.5}$ at sites in Bonners Ferry (Kootenai Tribe of Idaho), Sandpoint, Pinehurst and St. Maries. These sites collect air quality samples for comparison to the NAAQS on a predetermined sampling schedule. No samples were collected in Kootenai County with the $PM_{2.5}$ reference method. The sites in Bonners Ferry, Pinehurst and St. Maries operated on a one-in-three schedule and collected 24, 30 and 22 samples, respectively,

during the third quarter of 2003. The Sandpoint site operated on a one-in-six day sampling frequency and collected 15 samples during the third quarter.

Correlating the Federal Reference Method (FRM ) $PM_{2.5}$ data with agricultural burning and the CRD Smoke Management Program is difficult because the sampling schedule described above reduces the possibility that a sample day is also a burn day. For example, during the 2003 field burning season on the Rathdrum Prairie, the air quality sampling schedule overlapped with two burn days, August 19th and 25th, out of the eight total burn days. On August 19, Rathdrum Prairie growers burned 1,603 acres. The 24-hour average concentration measured downwind in Sandpoint was 6.0 $\mu g/m^3$. Field observations from that burn day confirmed that the smoke plume did not hit the Sandpoint area. No valid data was collected on the August 25 sample day.

The USEPA has presently established the $PM_{2.5}$ NAAQS at 65 $\mu g/m^3$ for the 24-hour standard and 15 $\mu g/m^3$ for the annual average. $PM_{2.5}$ concentrations above the NAAQS are unhealthy for the general public. The highest 24-hour concentration measured during the third quarter was 33.2 $\mu g/m^3$ at the St. Maries site on August 22. No agricultural burning was reported on August 22 in Kootenai or Benewah counties. Regional smoke from wildfires throughout the northwest appears to have influenced most of the high data points during the third quarter. Third quarter FRM data is presented in Figure 1 below.

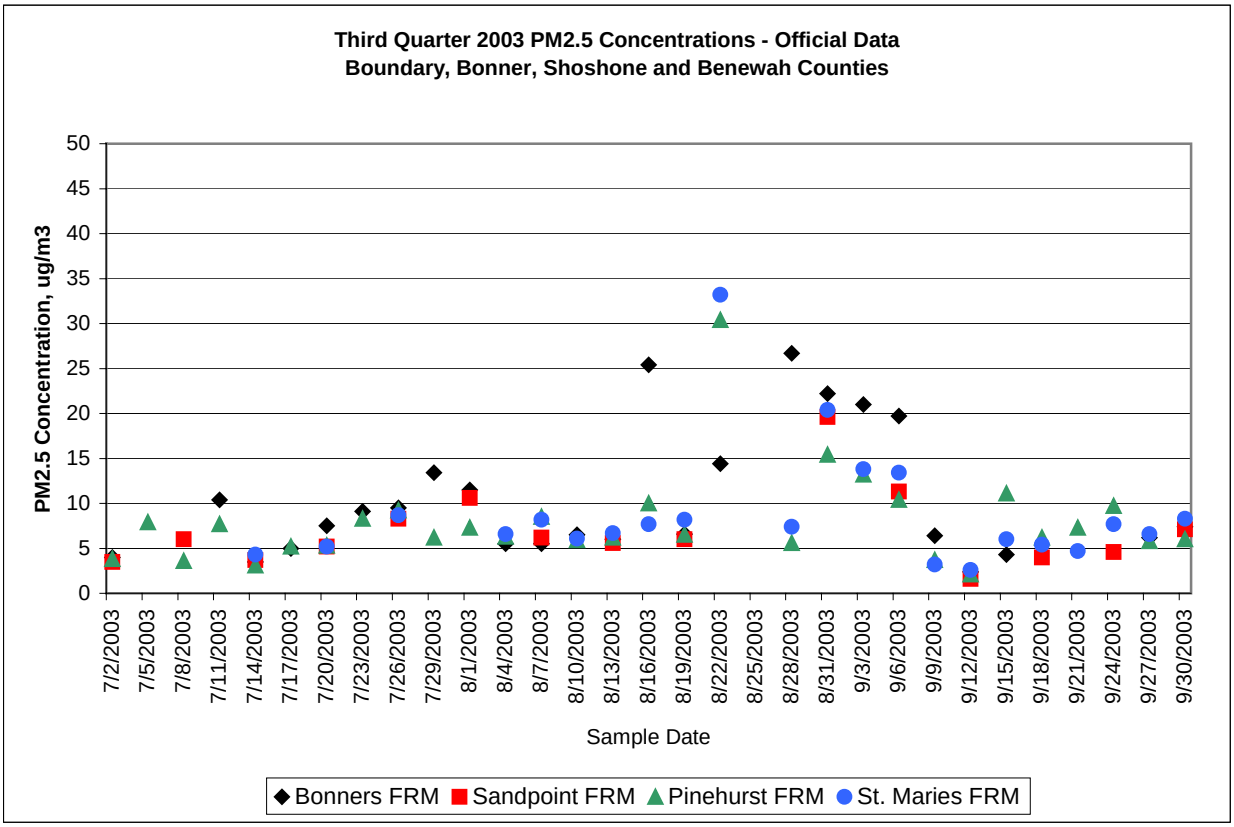


Figure 1. Third Quarter 2003 $PM_{2.5}$ FRM Data from Four North Idaho Monitoring Sites

Based on the FRM data, there were six days during the third quarter when $PM_{2.5}$ concentrations were above 15 $\mu g/m^3$ for the 24-hour average. $PM_{2.5}$ concentrations between 15.5 and 40.4 $\mu g/m^3$ fall into the Moderate Air Quality Index (AQI) category. Concentrations below 15.5 $\mu g/m^3$ are in the Good AQI category. When particulate concentrations increase and move into the Moderate range or higher, the health effects triggered by the higher concentrations become more noticeable. People with comprised respiratory systems or cardiovascular problems may be especially sensitive to increased particulate concentrations.

The FRM network provides the highest quality $PM_{2.5}$ data as a result of the state's quality assurance program and stringent federal guidelines. However, the data is not collected in real-time and only provides a single data point for a 24-hour period. The FRM sampling schedule is not continuous, so there is low probability of collecting a sample on a burn day. Smoke impacts that occur from agricultural burning are typically short-lived, between an hour to three hours in duration. Due to these limitations, the FRM sampling network does not provide adequate temporal resolution of $PM_{2.5}$ concentrations for smoke managers to evaluate the effectiveness of the smoke management program.

To improve the tracking of short-term changes in $PM_{2.5}$ concentrations for the CRD program, DEQ has invested in monitoring equipment that collects PM data continuously and reports hourly $PM_{2.5}$ or $PM_{10}$ concentrations. The types of equipment used and the location of monitoring sites are further discussed in the next section. These continuous methods provide more time resolved data but the collection method does not qualify as a reference technique per USEPA standards. The continuous data can be compared to the NAAQS but cannot be used to officially determine compliance with the NAAQS. These issues are also discussed in the following section.

Air Quality Monitoring Network

Due to the highly controversial nature of the CRD burning in north Idaho, the DEQ office in Coeur d'Alene developed a supplemental air quality monitoring network that is deployed seasonally for the CRD smoke management program to compliment the year-round monitoring network. Equipment for this supplemental network was funded primarily from Rathdrum Prairie grower registration fees that were managed by a local smoke management advisory committee. DEQ was an ex-officio member of the advisory committee when it was active from 1985 to 2003. Legislative changes in 2003 resulted in termination of the smoke management advisory committee in Kootenai County.

The supplemental network consists of four portable real-time samplers that are deployed in late July and removed from the field in late October or early November. DEQ designed and constructed these portable sampling stations to measure particulate matter continuously using a light scattering technique. The sampling platform includes a datalogger to store sample results and a phone modem for remote access. The equipment is housed in a weatherproof enclosure that is thermostatically controlled. Three samplers are strategically located at sites downwind of the Rathdrum Prairie. The general locations are in Rathdrum, north Hayden and Athol. A fourth site is located south of Coeur d'Alene near the Fighting Creek Landfill, which is adjacent to the northern border of the Coeur d'Alene Indian Reservation. Figure 2 shows the locations of these

four sites with regards to the Rathdrum Prairie and other year-round AQ monitoring sites maintained by DEQ.

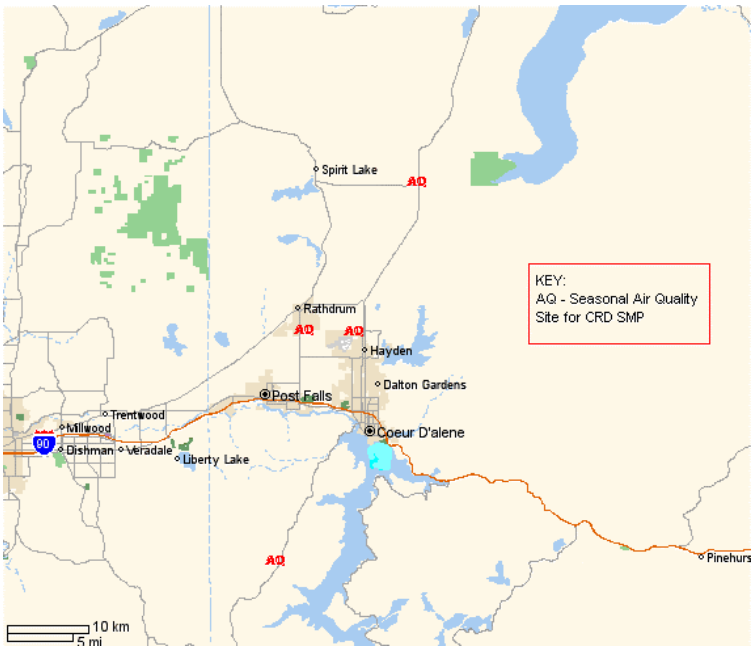


Figure 2. Map of Supplemental Air Quality Monitoring Sites in Kootenai County.

In 2003, funds were made available from an EPA grant to establish a new AQ monitoring site in Bonner County at the northeast end of Lake Pend Oreille. DEQ purchased a portable real-time PM sampler and established a new site in the community of East Hope. DEQ made the decision to invest in a different type of monitoring equipment for this site. One of the main reasons was that the new equipment did not require the same level of periodic maintenance as the other portable samplers. This was an important factor since the E. Hope site was located approximately two hours from the DEQ office.

DEQ maintains a fixed or year-round monitoring network at various locations throughout the four northern counties. DEQ also has developed partnerships with the Kootenai Tribe in Boundary County and with the Coeur d'Alene Tribe to provide technical assistance to their air quality monitoring programs. In 2003, DEQ had a special agreement with Louisiana Pacific Corporation to operate another site in Boundary County near Moyie Springs. Collectively, this network consists of a variety of instruments that collect data to support the state and federal air quality monitoring goals. DEQ's regional network includes both $PM_{2.5}$ and $PM_{10}$ monitoring equipment and meteorological monitoring as described below in Table 3.

Table 3. Description of Real-time Air Quality Monitoring Sites for 2003

| Location | County | Pollutant Measured | Sample Method |
|---|---|---|---|
| Bonners Ferry – Kootenai Tribe of Idaho | Boundary | $PM_{2.5}$ real-time | Nephelometer |
| Moyie Springs – LP Facility Moyie Springs | Boundary | $PM_{10}$ real-time | $PM_{10}$ TEOM |
| Coeur d'Alene - Lakes Middle School | Kootenai | $PM_{2.5}$ real-time<br>$PM_{10}$ real-time | $PM_{2.5}$ TEOM<br>$PM_{10}$ TEOM |
| Post Falls - Syringa Well Site | Kootenai | $PM_{2.5}$ real-time | $PM_{2.5}$ TEOM |
| Sandpoint – USFS Ranger Station | Bonner | $PM_{2.5}$ real-time | $PM_{2.5}$ TEOM |
| Sandpoint - Sandpoint Middle School | Bonner | $PM_{10}$ real-time | $PM_{10}$ TEOM |
| E. Hope – EBSD Pump Station | Bonner | $PM_{2.5}$ real-time | $PM_{2.5}$ EBAM |
| Athol - City Athol Well Site North | Kootenai | $PM_{2.5}$ real-time | Nephelometer |
| Rathdrum - Avista Odorizer Station | Kootenai | $PM_{2.5}$ real-time | Nephelometer |
| North Hayden - Boekel Rd & Hwy 95 | Kootenai | $PM_{2.5}$ real-time | Nephelometer |
| Fighting Creek - Kootenai Co. Landfill | Kootenai | $PM_{2.5}$ real-time | Nephelometer |
| Pinehurst - Pinehurst Elementary | Shoshone | $PM_{2.5}$ real-time<br>$PM_{10}$ real-time | $PM_{2.5}$ TEOM<br>$PM_{10}$ TEOM |

Air Quality Sampling Techniques and Equipment

1. FRM

Federal Reference Method (FRM) generally refers to the monitoring equipment that meets the USEPA requirements for measuring $PM_{2.5}$ for NAAQS determination. Data collected from these samplers are used to make the official determination of compliance with the $PM_{2.5}$ NAAQS. The FRM is the most accurate method for measuring this pollutant. The FRM sampler utilizes a filter-based sampling technique to collect a 24-hour integrated sample. Due to the rigorous quality assurance program for the FRM samplers, final data is not available until three months after sample collection.

The FRM samplers are also used to 'calibrate' non-reference method techniques such as the real-time samplers. DEQ has used the FRMs collocated with TEOMs and nephelometers to develop $PM_{2.5}$ data correlations for the non-reference techniques. DEQ operated FRMs in Sandpoint, Pinehurst and St. Maries during the 2003 field burning season. The Kootenai Tribe of Idaho also operated a FRM in Boundary County under a cooperative agreement with DEQ.

2. TEOM

DEQ operates and maintains an extensive network of TEOM (Tapered Element Oscillating Microbalance) samplers to measure $PM_{2.5}$ or $PM_{10}$ concentrations in real-time. TEOMs have the ability to continuously sample and measure PM concentrations. They can be configured to measure $PM_{10}$ or $PM_{2.5}$, depending on the data needs. In a $PM_{10}$ configuration, the TEOM data meets USEPA criteria for $PM_{10}$ as an equivalent method. DEQ submits $PM_{10}$ TEOM data to the EPA database on a routine basis for compliance determination with the $PM_{10}$ NAAQS. $PM_{10}$ TEOMs were operated in Coeur d'Alene, Sandpoint and Pinehurst.

Presently, there are no real-time methods approved by the USEPA for $PM_{2.5}$ sampling. In a $PM_{2.5}$ configuration, the data are also submitted to the EPA database but are not used for NAAQS compliance determination. DEQ collocates each $PM_{2.5}$ TEOM with a $PM_{2.5}$ FRM to establish a statistical correlation between the two instruments per an EPA protocol. DEQ operated $PM_{2.5}$ TEOMs in Sandpoint, Coeur d'Alene, Post Falls and Pinehurst during the 2003 fall season.

The TEOMs can provide a fairly accurate measure of hourly PM concentrations. They can also calculate 8-hour and 24-hour rolling averages. The data are accessible remotely through telemetry techniques such as modem communication protocols. DEQ is working to post the real-time PM data to websites for public access.

3. NEPHELOMETER

As mentioned previously, DEQ uses nephelometers to supplement the air quality network during the field burning season to increase the spatial measurement of $PM_{2.5}$ concentrations in real-time. The nephelometers measure $PM_{2.5}$ indirectly by application of light scattering technology. The method does not meet EPA's reference method criteria. The advantages of a nephelometer over a TEOM are cost and portability. The nephelometer that DEQ uses is approximately one-half the price of a TEOM. A nephelometer is also smaller and more portable than a TEOM, which makes them easier to set-up and locate at temporary sites. Nephelometer data are output to a datalogger which in turn processes the data into engineering units in 15 minute increments. The 15-minute data are post-processed to calculate hourly $PM_{2.5}$ averages. DEQ and the Kootenai Tribe operated five nephelometers during the 2003 field burning season at the locations described earlier. The Kootenai Tribe nephelometer runs year-round at the Tribal monitoring site.

4. E-BAM

The E-BAM is a small, portable continuous PM monitor that can be configured to sample $PM_{2.5}$ or $PM_{10}$. The E-BAM is smaller version of a beta attenuation sampler that has been approved by EPA as an equivalent real-time sampling method for $PM_{10}$. Beta attenuation involves the use of a radioactive isotope ($^{14}C$) to produce beta particles. A detector measures the decrease in beta particle intensity as particulates buildup on the filter. The change in beta energy can be related to the particulate concentration. The E-BAM does not meet EPA's reference method criteria for $PM_{2.5}$ measurements.

The new sampler was received in late June and was deployed in July to the new site in East Hope. The Hope E-BAM produced very erratic one-hour $PM_{2.5}$ concentrations and this irregular trend created concerns about the reliability and accuracy of the data during the field season. During the field burning season, one-hour EBAM data from the Hope site was compared to one-hour $PM_{2.5}$ TEOM data from Sandpoint and the comparison showed a poor correlation between the two sites for hourly data. The spatial separation of the two sites complicated the comparison and reduced the ability to trouble-shoot the performance problem. During the field season, DEQ changed some operating parameters such as the averaging period to improve performance.

After the field burning season ended, DEQ conducted a more thorough evaluation by moving and collocating the E-BAM with a $PM_{2.5}$ TEOM and FRM at the Pinehurst monitoring site in Shoshone County. This site was chosen because it measures high $PM_{2.5}$ concentrations during the winter season. The E-BAM ran for approximately two months at the Pinehurst site. The E-BAM data showed good correlation with the 24-hour FRM concentrations ($r^2 = 0.991$). Correlations of the hourly E-BAM data with the TEOM data were not as good ($r^2 < 0.6$) as compared to nephelometer and TEOM hourly collocated measurements ($r^2 > 0.9$).

In summary, a variety of air quality monitoring methods are used to characterize particulate concentrations in north Idaho. During the crop residue disposal smoke management season, additional equipment are deployed to better evaluate the spatial and temporal variability in PM concentrations that can exist when smoke plumes from field burning occurs. This data provides a quantifiable measure to the smoke management coordinators and air quality managers for decision making. The representativeness and quality of the data are important to the SMP. It is therefore important to acquire equipment and develop a network of sites that can meet the program objectives with available resources, knowing that fiscal constraints limit the ability to monitor in every possible downwind location.

Weather Observations

In addition to monitoring for pollutant concentrations, DEQ and the Kootenai Tribe of Idaho also maintain 10-meter meteorological towers (Table 4) that measure wind speed, wind direction, temperature, and other parameters on a continuous basis. The meteorological sensors are maintained and audited to meet USEPA quality assurance criteria for stationary source permitting programs. The data is processed by a datalogger into 15-minute increments and is remotely accessible through a telephone modem. DEQ maintained meteorological sites on the Rathdrum Prairie and in Sandpoint during the 2003 field burning season. The Kootenai Tribe of Idaho operates a meteorological site in Boundary County under a cooperative agreement with DEQ. The Kootenai Tribe meteorological tower has a similar compliment of sensors with the exception of barometric pressure and relative humidity. The Pinehurst meteorological site was not maintained per the DEQ Quality Assurance Plan during the 2003 field burning season due to budget limitations.

Table 4. Description of Real-time Meteorological Monitoring Sites for 2003

| Location | County | Parameters Measured |
|---|---|---|
| Rathdrum Prairie Met – South of City of Rathdrum | Kootenai | WS, WD, RH, solar radiation, Temp, BP |
| Univ. of Idaho Ag Research Station – Sandpoint | Bonner | WS, WD, RH, solar radiation, Temp, BP |
| Bonners Ferry – Kootenai Tribe of Idaho | Boundary | WS, WD, solar radiation, Temp at 2 m and 10 m |
| **Pinehurst Elementary School – City of Pinehurst | Shoshone | WS, WD, RH, solar radiation, Temp, BP |

Note: The Pinehurst met site was reactivated in September 2003 and became fully functional with QA/QC in January 2004.

The wind speed and wind direction data are especially important to the Crop Residue Disposal SMP. Surface wind speeds are part of the prescriptive conditions developed for each airshed that define burn/no-burn days. Surface wind direction is an important parameter in airsheds that have sensitive areas such as busy roadways or housing developments adjacent to the fields. Wind roses were developed from the 2003 data for the meteorological sites in Kootenai, Bonner and Boundary counties to evaluate the wind conditions during the CRD burn season. These wind roses are discussed in greater detail in the following sections for each airshed. The wind rose charts are found in Appendix B.

Burn Day Evaluations

The CRD smoke management program uses a number of environmental factors as part of the decision making process for determining a burn day. These environmental factors are described for each of the airsheds along with the burn decision process in the *Technical Guidance: Meteorological Services and Field Coordinators for the Idaho Crop Residue Disposal Smoke Management Program*, July 2003. Air quality pollutant levels, i.e., PM concentrations, are one of the many environmental indices considered. DEQ evaluates the air quality data routinely, not only to monitor the status of the network, but to also provide air quality information to the general public through the Air Quality Index (AQI) Program. The AQI program is a national program organized by EPA. Data from participating agencies are posted to the EPA AIRNOW website (www.epa.gov/airnow/index.html) daily along with an air quality forecast for the following day. DEQ submits data from each of the six regional offices to the AIRNOW program.

The AQI Program is a uniform method of reporting to the public about air quality and its relationship to public health. The AQI is divided into six categories with each category having a simple descriptor. As $PM_{2.5}$ concentrations increase from 15 $\mu g/m^3$ to 40 $\mu g/m^3$, air quality drops into the MODERATE category for the AQI. In the MODERATE category, visibility is reduced and the general public can generally notice the change, especially during this time of the year. In the past, $PM_{2.5}$ concentrations at the upper end of the MODERATE category have triggered a no-burn decision.

If $PM_{2.5}$ concentrations increase beyond 40 $\mu g/m^3$ for the 24-hour average and move into the UNHEALTHY FOR SENSITIVE GROUPS (USG) category of the AQI, then burning is not

recommended. DEQ can invoke a regulatory burn ban when $PM_{2.5}$ concentrations reach or are expected to reach 50 $\mu g/m^3$ for a 24-hour average. DEQ also has the authority (IDAPA 58.01.01.556) to issue a burn ban when one-hour $PM_{2.5}$ concentrations are expected to reach or have exceeded 80 $\mu g/m^3$.

The ISDA CRD Rule (IDAPA 02.06.16.500.02) requires that no new fires are ignited when $PM_{2.5}$ levels reach 80% of the one-hour criteria for $PM_{2.5}$ (80 $\mu g/m^3$) and are predicted to remain above those levels. When one-hour $PM_{2.5}$ concentrations reach or exceed 64 $\mu g/m^3$, the ISDA can prohibit the growers from igniting any additional fields. This regulatory requirement along with the DEQ one-hour $PM_{2.5}$ criteria necessitates that smoke managers pay close attention to air quality conditions during the burn season.

As described in the previous section, there are a number of AQ monitoring sites that can provide real-time information on $PM_{2.5}$ and $PM_{10}$ concentrations in airsheds with CRD burning. DEQ has provided training and software to field coordinators so that they can directly access the monitoring sites in their area. This direct access provides the field coordinators with the same level and accessibility to data as DEQ. On the Rathdrum Prairie, one field coordinator was dedicated to tracking PM concentrations at the real-time monitoring sites. In Boundary County, the ISDA field coordinator had limited access to air quality data during the 2003 burn season. The Kootenai Tribe site was the only PM monitoring site in the Kootenai River Valley where the spatial coverage of air quality monitoring is less dense than Kootenai County. Across the US-Canadian border, the City of Creston, British Columbia, has a $PM_{10}$ TEOM with data posted to a website on an hourly basis.

$PM_{2.5}$ levels were monitored daily during the burn season and was a regular topic of discussion during the afternoon and morning burn SMP conference calls with the field coordinators. The ultimate responsibility for making the daily burn decision and giving approval to the grower to burn rests with the ISDA. This responsibility is shared between the field coordinators at the local level and the program manager who oversees the statewide program. Because of the regulatory limits for $PM_{2.5}$ concentrations that are in place by state rule, air quality data is extremely important to SMP.

In 2003, smoke from regional and local wildfires contributed to elevated $PM_{2.5}$ concentrations intermittently during the season. In general, as ambient concentrations of $PM_{2.5}$ increase from wildfire smoke, it reduces the ability of the CRD burn team to recommend a burn decision that could potentially add more smoke to an already smoky airshed. Coordinating the burn decisions during the wildfire season adds an additional layer of complexity to the program. An airshed may meet all the meteorological criteria for a good burn day as outlined in the airshed prescriptions but poor air quality, i.e. smoke from wildfires, can result in a no-burn decision. Specific examples of the burn decisions and wildfire impacts are discussed in the following sections for each airshed.

## AIRSHED DISCUSSION – Rathdrum Prairie

### Overview

The Rathdrum Prairie is an area of irrigated agricultural fields and other rural land in Kootenai County. The Rathdrum Prairie is bordered to north by the city of Rathdrum and to the east by the city of Hayden, and to the south by the cities of Post Falls and Coeur d'Alene. In 2003, growers registered 4,118 acres of bluegrass seed fields for the CRD program. This represents the fewest number of acres registered on the Rathdrum Prairie since 1987. Growers were able to complete burns on 3,842 acres during eight designated burn days (Table 5). Daily burn acres ranged from a low of 7 acres for a test burn to a high of 1,603 acres.

Table 5. Summary of Rathdrum Prairie Burn Days, $PM_{2.5}$ Concentrations and Hotline Calls.

| **2003 Burn Days** | **Acres Burned** | **Max. 1-hour $PM_{2.5}$ Conc.**, $\mu g/m^3$ | Hour Ending Time Period, PST | AQ Monitoring Site | Complaints Reported by Hotline |
|---|---|---|---|---|---|
| Tuesday July 31 | 40 | 31 | 9 pm | Post Falls | 1 |
| Wednesday August 6 | 117 | 29 | 3 pm | Athol | 18 |
| Monday August 11 | 385 | 17 | 8 pm | Coeur d'Alene | 55 |
| Tuesday August 12 | 815 | 69 | 2 pm | N. Hayden | 94 |
| Tuesday August 19 | 1603 | 71 | 1 pm | Athol | 7 |
| Wednesday August 20 | 7 | 49 | 1 pm | Athol | 4 |
| Monday August 25 | 494 | 70 | 2 pm | Athol | 22 |
| Tuesday August 26 | 381 | 53 | 8 pm | Coeur d'Alene | 19 |

Historically, growers have also registered acres that were not on the Rathdrum Prairie but still in Kootenai County and not within the borders of the Coeur d'Alene Indian Reservation. These fields were located in the Fighting Creek area just north of the reservation boundaries, and in the eastern portion of Kootenai County near Cataldo along the Coeur d'Alene River. The grass fields in the Cataldo area are not a Kentucky bluegrass variety and are generally harvested after the bluegrass fields on the Rathdrum Prairie are burned. No acres were burned from either of these two outlying areas.

Prior to 2003, growers on the Rathdrum Prairie agreed not to burn on Fridays and to limit the total number of burn days to fourteen per year during a 45-day window. These voluntary restrictions were not part of the statewide rules for CRD burning. During the 2003 season, the growers choose not to exercise the voluntary restrictions and Fridays were included in the burn day evaluation process. In the end, no burning occurred on a Friday during the 2003 season on the Rathdrum Prairie.

### Burn Day Evaluations

The field coordinators on the Rathdrum Prairie have an abundance of data to evaluate for making a burn decision. As described earlier, a relatively dense network of air monitoring stations provides $PM_{2.5}$ concentrations at a number of locations upwind and downwind of the burn area (Figure 2). Table 5 identifies the eight burn days on the Rathdrum Prairie in 2003, the acres burned each day, the maximum one-hour $PM_{2.5}$ concentration recorded, and the hour the concentration was recorded. Of the eight burns, three days recorded one-hour $PM_{2.5}$ concentrations that exceeded the CRD 64 $\mu g/m^3$ limit during the early afternoon hours of the burn day. The impacts were recorded at only one of the downwind sites for each event. The

nephelometer at the north end of Hayden (Meyer Ranch site) picked up the high concentrations during the August 12th burn day. The Athol site reported the $PM_{2.5}$ concentrations greater than 64 $\mu g/m^3$ on August 20 and August 25. These smoke impacts are illustrated in Figure 4. The average hourly $PM_{2.5}$ for the month of August was 11.6 $\mu g/m^3$ based on data from the Post Falls and Coeur d'Alene $PM_{2.5}$ TEOM data.

The airshed prescription for the Rathdrum Prairie does not presently identify a background $PM_{2.5}$ concentration that triggers a no-burn decision. Generally, if the background concentration has risen above 15 $\mu g/m^3$ for the 24-hour average, then more consideration was given to the increased PM levels during the burn decision process.

Graphs of the hourly data from the TEOMs and nephelometers, like those shown in Figures 3 and 4, provide some clues about the source(s) that contribute to the elevated concentrations. Typically, large wildfires produce smoke impacts that are widespread and dispersed across large geographic areas. Under these conditions, all of the monitoring sites in northern Idaho will measure elevated PM levels and the trend lines for each site follow a similar trace.

Significant smoke impacts from wildfires were observed in August 2003, especially on the 15th and 16th. Ambient concentrations of $PM_{2.5}$ rose from approximately 10 $\mu g/m^3$ to 40 $\mu g/m^3$ for hourly averages. A maximum hourly $PM_{2.5}$ concentration of 106 $\mu g/m^3$ was observed in Sandpoint on August 15, resulting in a 24-hour concentration of 59 $\mu g/m^3$ for that same day. DEQ issued a Stage One Forecast and Caution for Bonner County on August 15. This invoked an air quality burn ban for that same area. All forms of open burning are prohibited when a Stage One Forecast and Caution is issued. A post-season review of the data from Boundary County showed that high $PM_{2.5}$ concentrations were also measured at the Kootenai Tribe site for the same time period and DEQ should have extended the burn ban to also include Boundary County. Air quality improved the following day and the burn ban was lifted for Bonner County on Saturday afternoon, August 16th.

Smoke impacts from agricultural field burning tend to be more localized and peaks show up at only one or two of the monitoring sites. Burn days on the Rathdrum Prairie can usually be identified from the nephelometer data when short-term smoke impacts are recorded at one or two downwind sites. For example, Figure 4 shows the distinct one-hour peaks that represent localized impacts during five of the eight burn days; August 6, 11, 12,19, and 25. More detailed resolution of the hourly $PM_{2.5}$ impacts is provided in Appendix A – ClearSky Modeling Results and AQ Data. Additional discussion of the hourly impacts follows in the section on the ClearSky Analysis.

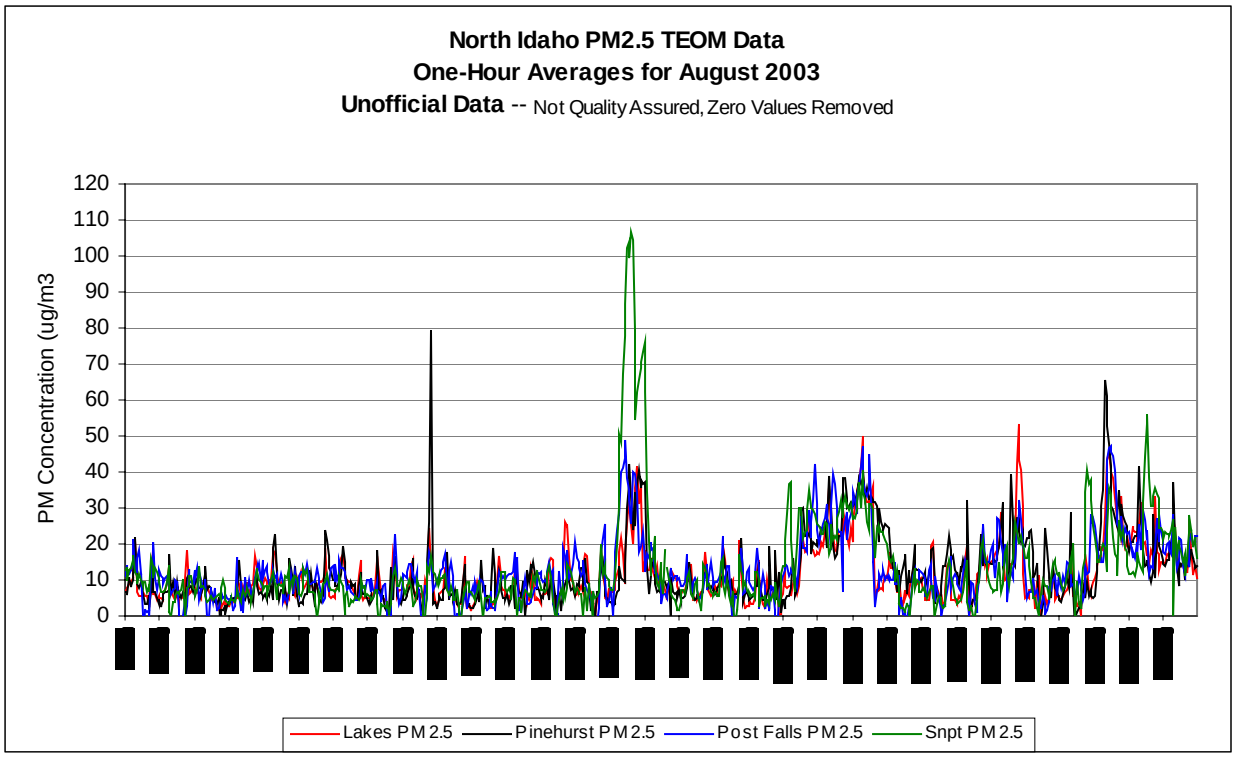


Figure 3. One-hour Average $PM_{2.5}$ Concentrations from TEOM Sites in North Idaho.

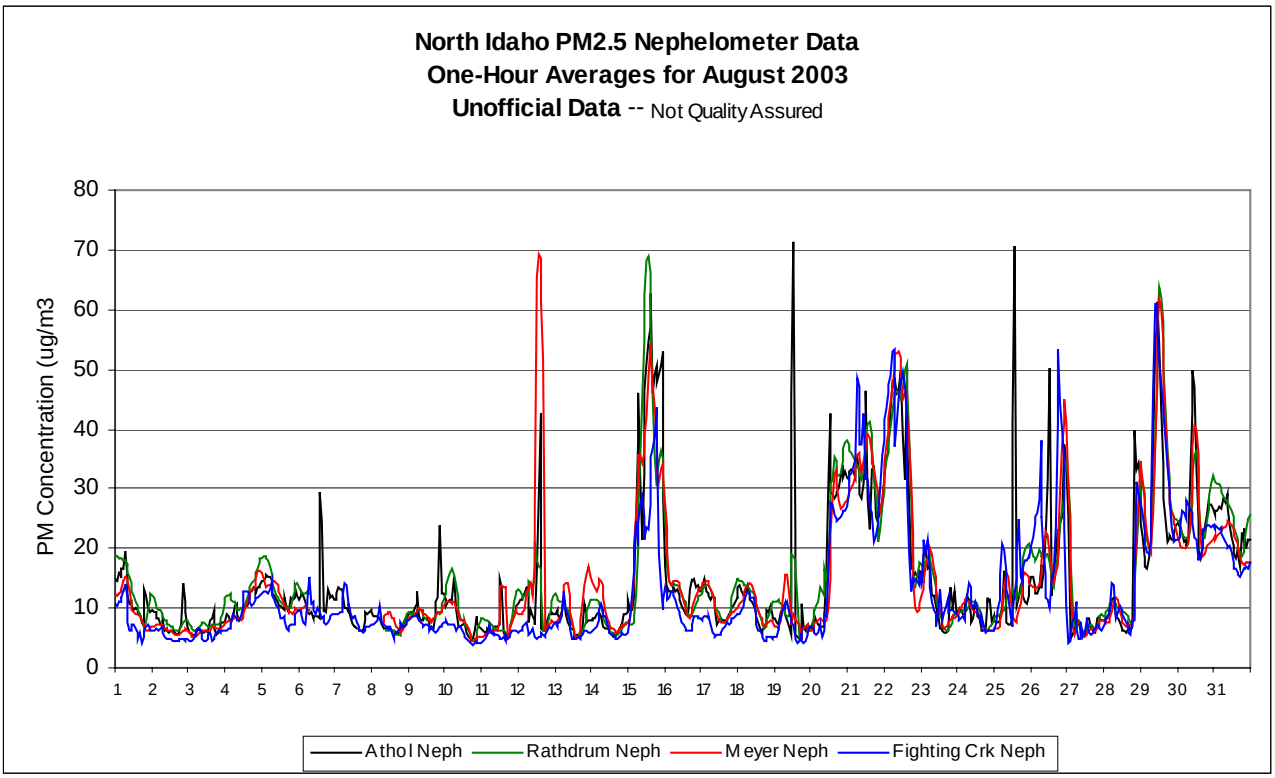


Figure 4. One-hour Average $PM_{2.5}$ Concentrations from Nephelometer Sites in North Idaho.

During the 2003 season, background $PM_{2.5}$ levels in Kootenai County were generally low enough to not restrict the burn decision process. When significant smoke impacts from wildfires

did increase the background level, these events occurred on weekends when agricultural burning is prohibited by the CRD rules. One exception occurred on Wednesday, August 20, when $PM_{2.5}$ concentrations began to climb in the early afternoon from wildfire smoke. It was a designated burn day on the Rathdrum Prairie with nearly 1,000 acres approved for burning. After observing a seven-acre test burn, the field coordinator cancelled any additional burning due to rising $PM_{2.5}$ concentrations (Figure 4).

The smoke management CRD program needs to identify a background level for the Rathdrum Praire prescription that will trigger either a Conditional or No-burn decision. Presently, field coordinators and SMP managers have not formalized a level at which this action occurs. DEQ recommends that ISDA adopt a background level between 30 to 40 $\mu g/m^3$ (24-hour $PM_{2.5}$ concentrations) at which a no-burn decision is triggered by the SMP. When $PM_{2.5}$ concentrations rise above 40 $\mu g/m^3$ for a 24-hour average, DEQ will issue an Air Quality Advisory to alert the public that air quality conditions have changed into the Unhealthy for Sensitive Groups category. More discussion and analysis is needed prior to recommending a one-hour $PM_{2.5}$ concentration for the no-burn trigger.

Weather Forecasts

In the burn decision process, forecasting the weather is probably the most difficult part of the equation. Field coordinators have a number of tools available to them to aid them in their burn recommendation. These tools are described briefly in the *Technical Guidance: Meteorological Services and Field Coordinators* document, July 2003. In addition to the various products that are available through the Internet, a weather forecast and a burn recommendation specific to the Rathdrum Prairie were provided twice per day from the contract meteorological service supporting the SMP. This SMP forecast included an hourly ventilation rating during the burn time period (8 a.m. to 5 p.m.) and a burn recommendation (no burn, conditional or burn).

For local weather data, the Rathdrum Prairie field coordinators had access to surface observations collected by the DEQ meteorological station, the Coeur d'Alene Airport data posted on the Internet, and direct observation with hand-held sensors or other instruments. The field coordinators also measured upper air parameters by releasing pilot balloons (pi-bals) and tracking their movement through the atmosphere. Pibals were released on the Rathdrum Prairie and on the Coeur d'Alene Indian Reservation in Plummer. The field coordinators process pibal data to determine wind speed and wind direction at one-minute intervals through the atmosphere. During a typical observation, winds are observed to a height of approximately 9,000 to 12,000 feet above ground level.

Historically, the pibal data was an important tool for burn coordinators on the Rathdrum Prairie. This tool played a significant role in the burn decision process. In the past, this focus on the use of pibal data may have contributed to burn decisions that resulted in significant smoke impacts to populated areas, either from unexpected changes in weather or from overloading the dispersion capacity of the atmosphere with smoke from too many burned acres. As the SMP continues to evolve, there is a greater emphasis on the use of sophisticated forecast models to evaluate downwind transport of smoke plumes. The pibal data continues to be an important and practical tool for smoke coordinators. The field coordinators should use the pibal data to ground-truth or

validate various modeled forecast products such as the upper air winds in the 850mb or 700mb products.

The pibal data can accurately show wind direction and wind speed for the general location of the balloon release. This can be a useful tool especially if the observation is near the fields planned for burning. The pibal data is very useful information for identifying proper weather conditions at the point of ignition especially in areas where there are numerous sensitive zones close to the grass fields and the margin of error is small.

Pibal data are not as useful for long-range downwind dispersion. Topography and terrain can have a significant influence on surface wind conditions. Pibal measurements from the Rathdrum and Plummer sites for the same elevation and time period can be significantly different. The accuracy of the data is also a concern. Error can also be introduced from recording the field measurements and is inherent in the calculations that assume a constant rate of balloon rise. Other environmental parameters effect the accuracy of the pibal measurements. Downwind features such as large water bodies or mountain ridges can produce atmospheric effects that are not represented by the pibal measurements. Therefore, additional tools such as the MM5 forecasts and ClearSky dispersion model are necessary for the prediction of regional plume movement. In sensitive airsheds such as the Rathdrum Prairie, regional smoke impacts can occur beyond the field of view of the field coordinator and the area of ignition. The sophisticated computer models factor in the influences of terrain, topography and other phenomenon that affect the movement of air masses in both horizontal and vertical planes.

Case Study – August 13, 2003

In this case study, a simplified analysis of the upper air winds represented by the 850mb wind charts, obtained from the University of Washington MM5 public website, were compared with winds measured by pibal observations from the Rathdrum Prairie and Plummer area. This case study will provide a cursory overview of the accuracy and limitations of each tool.

The 850mb wind predictions are available from various forecasting models such as MM5. These charts represent upper air winds that are generally at 5,000 feet above mean sea level. The Coeur d'Alene airport has an elevation listed at 2,320 feet above mean sea level. To interpolate the 850mb charts for this area, the elevation of the airport was subtracted from 5,000 feet. Therefore on the Rathdrum Prairie, 850mb wind charts represent winds at approximately 2,700 ft above ground level (agl). Figure 5 shows an example of forecasted winds at 850mb at 4 km grid resolution for an area that includes Washington, Oregon, the western third of Idaho, and the southern edge of British Columbia. This forecast product was downloaded from the MM5 website, www.atmos.washington.edu/mm5rt, for August 13, 2003 at 7 a.m. PDT.

The forecast winds can then be compared to the wind data that is collected by the pibal observations. The pibal analysis divides the wind measurements into a series of layers at one-minute intervals. The observer may take 15 to 20 balloon observations at one-minute intervals. From each one-minute measurement, a wind speed and wind direction is calculated for an elevation above the ground level (observation point). The post-season analysis of the pibal data and upper air forecasts from MM5 presented in this section was limited to the availability of images archived from the MM5 website that match up with pibal run times. The following

discussion evaluates conditions on August 13, 2003 that led to a no-burn decision on the Rathdrum Prairie.

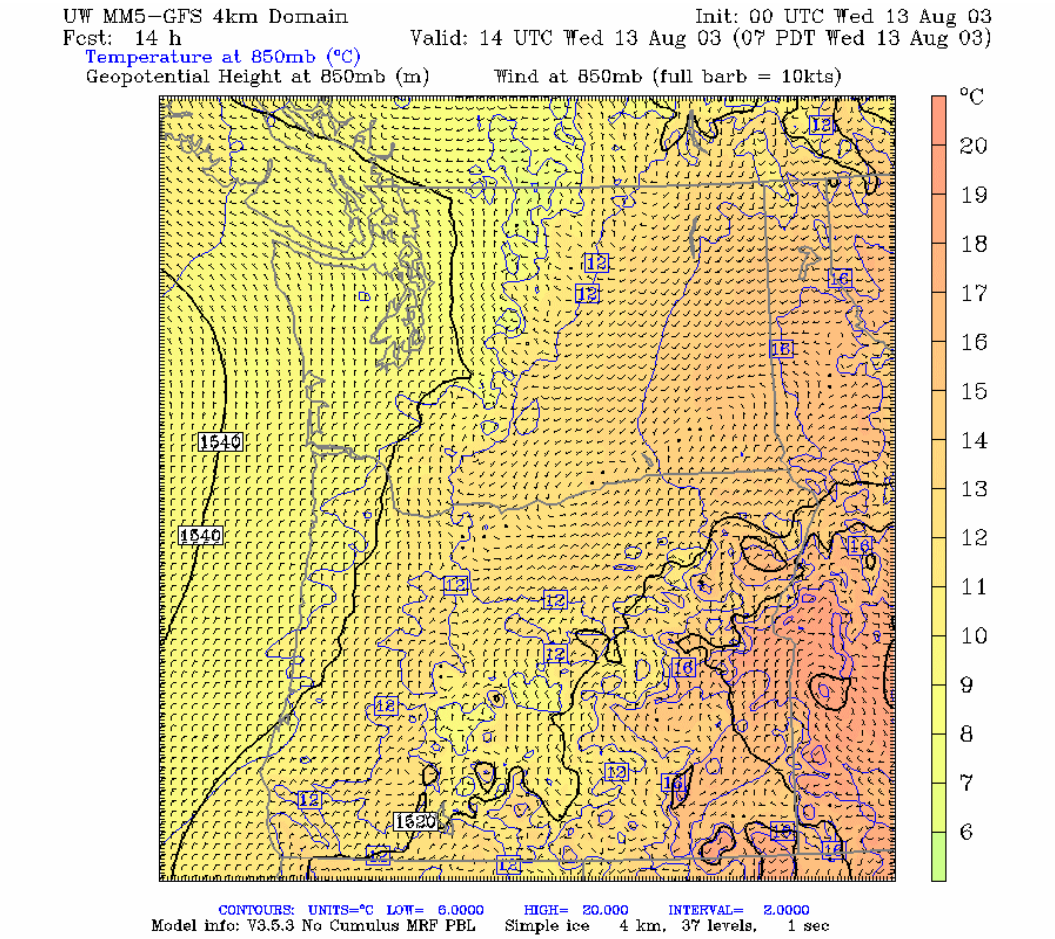


Figure 5. MM5 Forecast Product for 850mb Temperature and Winds for August 13, 2003.

In the pibal analysis, the layers or time intervals at minutes 4 and 5 provide wind speed and direction at elevations of 2,630 and 3,250 feet above ground level, respectively. These pibal layers are roughly equivalent to the 850mb wind products over the Rathdrum Prairie. The Coeur d'Alene Tribe uses pibal software produced by the Oregon Department of Agriculture. Figure 6 shows an example of a morning pibal run taken by the Coeur d'Alene Tribe in Plummer at 7:30 am PDT on August 13. The Oregon software calculates the average layer winds and generates graphs of the layer wind speeds (Profile) and the balloon path (Hodograph). Figure 7 shows a polar chart of the upper air winds derived from a pibal run on the Rathdrum Prairie later that same morning. The Rathdrum Prairie field coordinators use an older pibal software application that also calculates the average layer winds and produces the polar wind chart.

On August 13, field coordinators completed pibal runs on the Rathdrum Prairie at the following times: 0725, 1000, and 1100 hrs PDT. For this review, only a 7:30 am PDT pibal run from Plummer was available. When the winds measured by the Rathdrum pibal are compared to the winds interpolated from the MM5-GFS 4km 850mb run (Figure 5), they generally show good agreement for wind direction. Table 6 shows the wind directions and wind speeds for each hour.

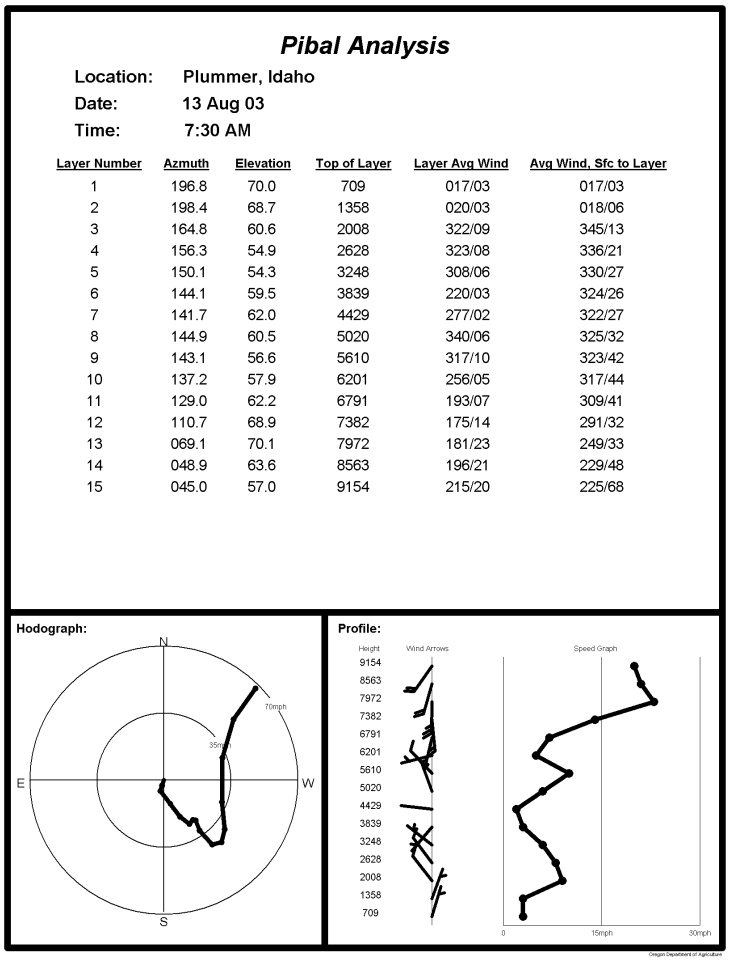


Figure 6. Pibal Analysis from the Coeur d'Alene Tribe for August 13, 2003 at 0730 hrs PDT.

Both the MM5 850mb forecasted values and the Rathdrum Prairie pibal results showed that the upper air winds shifted during the morning from a westerly flow to a northwesterly direction. Northwest transport winds are not desirable wind condition based on the burn prescription for the Rathdrum Prairie (*Technical Guidance document*, July 2003). In this particular case, the predictive capabilities of the model were relatively accurate for the time of day and location when compared to the observed conditions. The pibal runs from both locations showed that the upper winds turned significantly with increasing height above ground. Additional analysis of other upper air winds such as the 700mb wind charts (10,000 ft above msl) could help further with reconciling the model results with observations.

Table 6. Predicted versus Observed Wind Direction and Wind Speed for August 13, 2003

| Time PDT | Rathdrum Prairie Pibal WD, degrees | Rathdrum Prairie Pibal WS, knots | Plummer Pibal WD, degrees | Plummer Pibal WS, knots | MM5 850 mb WD, degrees | MM5 850mb WS, knots |
|---|---|---|---|---|---|---|
| 0730 | 262 | 3 | 323 | 8 | 240 | 10 |
| 1000 | 270 | 5 | NA | NA | 285 | 5 |
| 1100 | 290 | 8 | NA | NA | 315 | 5 |

MM5 wind direction and speed interpolated from wind barbs.
Additional morning pibal runs from Plummer were not available for August 13.

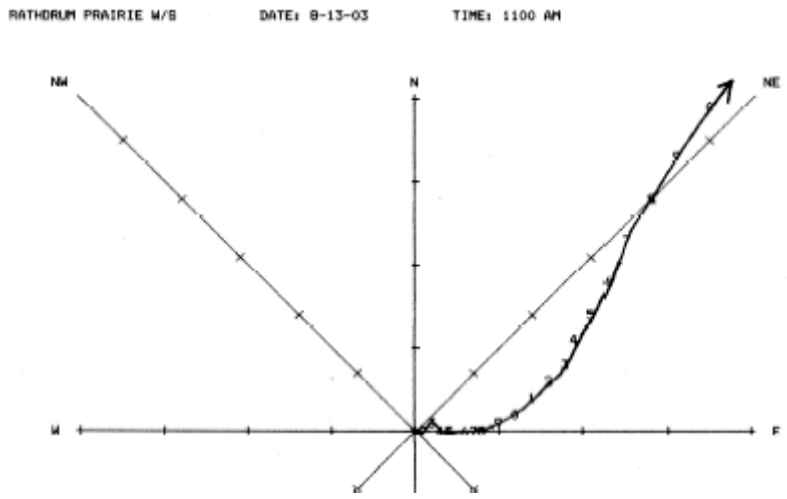


Figure 7. Rathdrum Prairie Pibal Run from August 13, 2003 at 1100 PDT.

The final decision by the Rathdrum Prairie field coordinator later that morning was a No-Burn decision. This was a difficult decision because the pibal readings at higher elevations (5,000 ft. agl and higher) showed the wind shifting to a more southwesterly direction (Figure 7), which does meet the prescription criteria for the prairie. The forecast and burn recommendation from the contract meteorologist listed the airshed in the conditional category. The morning ventilation rating forecasted marginal ratings from 12 p.m. to 5 p.m.

The No-Burn decision was further supported by the ClearSky default runs for August 13. The default ClearSky run for the Rathdrum Prairie was designed to represent burning 1,500 acres distributed across the prairie. The model results from the ClearSky August 13 run showed that the plume from burns on the Rathdrum Prairie moved east/southeast and impacted the adjacent cities of Hayden and Coeur d'Alene. Figure 8 shows the modeled plume location for the hour ending at 2 p.m. (1400 hrs) PDT. There are two distinct plumes seen in the ClearSky model run shown in Figure 8. One plume is from the Rathdrum Prairie and the other is from burning within the Coeur d'Alene Reservation boundaries. Both plumes moved to the southeast. The ClearSky results are described further in the next section.

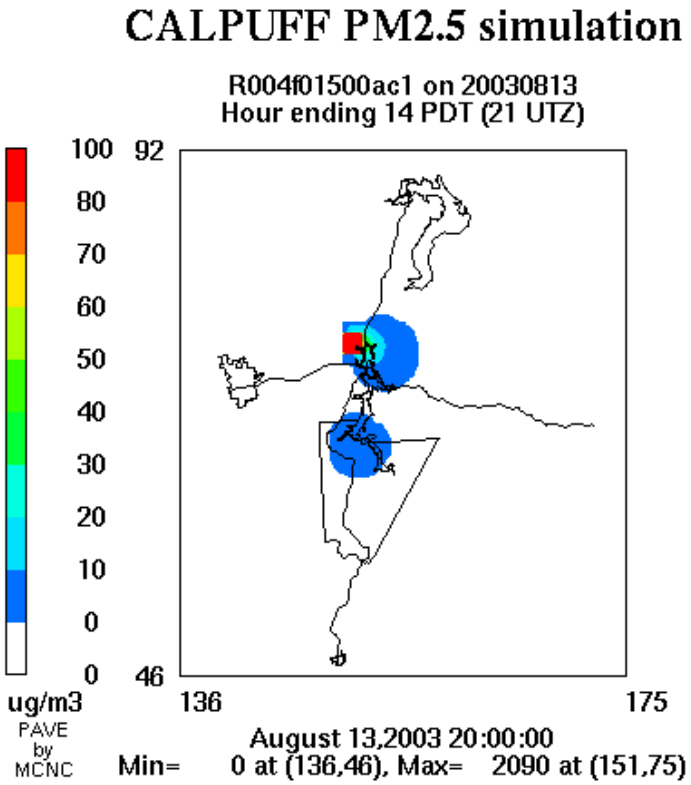


Figure 8. ClearSky Model Run for August 13, 2003 at 14:00 PDT with default burn scenario.

As discussed in this case study, the field coordinator had a number of tools available to evaluate the weather conditions and make a final burn decision. This is by no means an easy process with black and white answers. The field coordinator must evaluate a number of parameters based on actual observations and model forecasts to make an accurate and reliable decision. With experience and training, the field coordinator can learn to use the actual field observations to evaluate the accuracy of the forecast products such as MM5 and then determine their relative importance or significance. The field coordinator must have the skill and technical resources to make these decisions in a short amount of time while juggling other tasks such as coordination with growers and public notification. The potential for error always exists especially when it involves weather predictions. Therefore, the final decision should always error on the side of caution in order to protect the public from prolonged exposures to smoke.

ClearSky Analysis

The ClearSky model was designed to provide smoke managers with a tool to estimate long-range plume movement and as the model improves, test various burn acreage scenarios to judge the airshed capacity to disperse smoke. ClearSky was operational for the Rathdrum Prairie and Coeur d'Alene Indian Reservation during the 2003 burn season. The model was programmed to run daily default scenarios for burns in these two smoke management areas. Field coordinators and DEQ staff could also submit proposed scenarios that might closely replicate the burns planned for the following day.

During the 2003 season, the Rathdrum Prairie field coordinators submitted alternative scenarios on a regular basis to evaluate various amounts of acreage burned on a daily basis. A default scenario of 1,500 acres ran daily. Field coordinators routinely submitted other scenarios varying between 400 and 900 acres during the later part of the season.

The ClearSky runs for each of the eight burn days on the Rathdrum Prairie are presented in Appendix A. The $PM_{2.5}$ air quality data is also presented with each burn day on an hourly basis. A select number of No-Burn day model runs are also included in Appendix A. The following discussion summarizes the model runs for each day and how well they represented direct observations of the plume and actual air quality measurements.

August 6 – 117 acres Burned

The ClearSky default run showed a smoke plume moving to the east and impacting the adjacent cities of Hayden and Coeur d'Alene. The maximum $PM_{2.5}$ impact predicted by model run was 545 $\mu g/m^3$. The ambient monitoring network showed a maximum impact of 29 $\mu g/m^3$ at the Athol site. The monitoring site on the east side of Coeur d'Alene did not record a noticeable increase in $PM_{2.5}$ concentrations.

The Rathdrum pibal measurements did not correlate well with the ClearSky plume movements. The pibal reading at 1000 hrs PDT showed surface winds from the east changing to a northerly direction with increasing elevation until about 5,000 ft agl. At elevations above 5,000 ft. agl, the winds changed course 180° and became a strong southwest wind from 6,000 ft. agl to 8,000 ft. agl.

August 11 – 395 acres Burned

The ClearSky model showed the smoke plume (default acres) moving to the northeast from the Rathdrum Prairie. The model predicted a maximum $PM_{2.5}$ concentration of 61 $\mu g/m^3$ at 1300 hrs PDT. The monitoring network recorded a concentration of 15 $\mu g/m^3$ at the Athol site at 1200 hrs PDT.

The Rathdrum pibal correlated reasonably well with the ClearSky plume movement. The pibal chart at 1135 hr PDT showed winds out of the southwest with a west/northwest component at 3,000 to 4,000 ft. agl before the winds turned back to a more southerly direction.

August 12 – 815 acres Burned

ClearSky model runs on this day showed smoke plumes moving from the prairie to the southeast over the cities of Hayden and Coeur d'Alene. The default run (1,500 ac.) predicted a maximum $PM_{2.5}$ concentration of 1,363 $\mu g/m^3$ at 1400 hrs PDT. Smoke impacts were measured at the Meyer Ranch nephelometer site on the east side of the prairie with concentrations peaking at 69 $\mu g/m^3$ at 1300 hrs PDT. Smoke impacts were also recorded further north at the Athol site. The ISDA CRD rules identify a limit of 64 $\mu g/m^3$ for a one-hour average $PM_{2.5}$ concentration that terminates field burning.

A pibal run at 0930 hr PDT showed variable winds that switch around with elevation. Southwest winds switch to northwest winds and then turn 180° to become southeast

winds between 5,000 to 6,000 ft. agl. Eventually the winds turn back to a southwest component above 10,000 ft. agl. The ClearSky and MM5 850mb products correlate well with the pibal results for the elevation from 2,500 to 3,500 ft. agl.

The benefit of having pibal data is evident from this burn day. The pibal results show the variability that exists with the wind direction and speed with increasing height through the atmosphere. Inherent in the ClearSky modeling results is an analysis of multiple layers of winds and the combined physical effects of the wind layers on the vertical and horizontal movement of the smoke plume. However, the ClearSky results only show the predicted $PM_{2.5}$ concentrations of the plume in the surface layer (<20 meters). Interpreting the results of each product and knowing the strengths and limitations of each is important in using the different products to formulate a final burn decision.

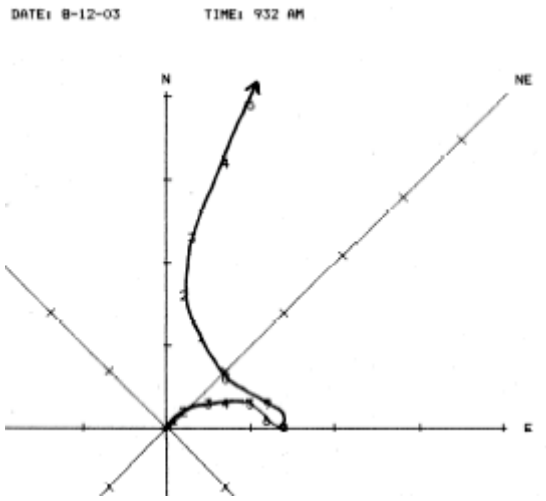


Figure 9. Rathdrum Prairie Pibal run for August 12, 2003.

August 19 – 1,613 acres Burned

This day was the largest burn day on the prairie for the 2003 season. The ClearSky default run showed a smoke plume that moved to the northeast from the Rathdrum Prairie and dispersed quickly. The maximum predicted concentration was 58 $\mu g/m^3$ at 1300 hrs PDT. The monitoring site at Athol recorded a maximum concentration of 71 $\mu g/m^3$ at 1200 hrs PDT.

Unfortunately for this analysis, only one pibal run from the Rathdrum Prairie was available and it was an early morning analysis taken at 0712 hrs PDT. The pibal analysis correlated well with the ClearSky plume movements despite the time difference. The morning pibal analysis showed a fairly consistent wind direction from the surface to 10,000 ft. agl.

The ClearSky plume predictions and the pibal runs both showed winds that met the prescription for this airshed. On the ground observations showed that the smoke plume followed a path very similar to the model predictions and dispersed in nearly the same time sequence. On this particular day, the model forecasts and the actual plume behavior

and measurements correlated very well. Air quality staff tracked the plume downwind and noted that the smoke plume descended over Lake Pend Oreille. The photograph in Figure 10 shows the smoke layer above the surface of the lake. The subsidence effect of the lake resulted in more surface level smoke impacts in the Hope area than anticipated by the SMP coordinators.

Figure 10. Photograph from the west side of Lake Pend Oreille with smoke layer approximately 200 ft above the surface. August 19, 2003 at 1435 PDT.

August 25 – 495 acres Burned

A ClearSky model run was created for 455 acres on the Rathdrum Prairie. The smoke plume forecast from this run showed a plume that moved to the north/northeast and meanders over the Sandpoint area. No significant ambient impacts were predicted by ClearSky. The maximum predicted ambient concentration was 12 $\mu g/m^3$. The ambient monitoring network recorded a $PM_{2.5}$ concentration of 70 $\mu g/m^3$ at the Athol site at 1300 hrs PDT. No other downwind impacts were recorded by the monitoring network. On this day, the ClearSky model underestimated the $PM_{2.5}$ concentrations at a downwind location.

The Rathdrum pibal run taken at 0945 hrs PDT showed a fairly consistent wind profile with a west/southwest component. Winds closer to the surface were from the southeast turning to a southwest wind at approximately 2,000 ft. agl.

August 26 – 381 acres Burned

The field coordinator entered a scenario for 381 acres the previous day so that the ClearSky model run matched the planned burn for August 26. The model forecast showed a smaller plume that moved to the northeast. The maximum downwind impact predicted by the model run was 28 $\mu g/m^3$ at 12 PDT. The Athol monitoring site recorded a maximum of 50 $\mu g/m^3$ for the same hour. A default run of 1,500 acres was also run for the same day. As expected, it showed a much larger plume moving in the same direction as the 381 acre run. The maximum downwind impact predicted by the default run was 72 $\mu g/m^3$ at 14 PDT.

The Rathdrum pibal run at 0900 hrs PDT recorded a constant southwest wind from the surface up to 10,000 ft. agl. Both the pibal run and ClearSky showed winds that met the prescription for the Rathdrum Prairie.

Appendix A also includes ClearSky runs from two No-burn days, August 5 and August 7. The meteorological forecasts for both days were conditional and no-burn recommendations, respectively, due to unfavorable dispersion conditions. Wet field conditions were also a contributing factor due to a rain event earlier in the week. The ClearSky runs showed smoke plumes moving to the southwest on August 5 and to the southeast on August 7. These runs show plume movements that do not meet the airshed prescription. The morning pibal runs on each day show wind conditions in the lower levels that do not meet the airshed prescription. On both the 5$^{th}$ and 7$^{th}$ of August, winds above 3,500 ft. agl changed to a northerly wind. The ClearSky runs showed plume movements that matched the pibal observations below 3,500 ft. agl. The ClearSky runs showed slow moving plumes that resulted in predicted maximum concentrations on August 5 of 2,033 $\mu g/m^3$ at 13 PDT and 458 $\mu g/m^3$ at 14 PDT on August 7.

In summary, the ClearSky model produced predicted plume movements that matched reasonably well with actual observations of wind conditions on the Rathdrum Prairie. The ClearSky results showed better agreement with observed conditions when the observed winds moved in a constant direction with increasing elevation through the boundary layer. Observations that showed turning or looping winds resulted in the most conflict with the ClearSky runs. These conditions also presented the greatest difficulty for the field coordinators faced with the process of reconciling the various forecast products with actual observations such as pibal runs. Under these meteorological conditions, i.e. significant turning winds, the field coordinators need to know how the actual field burns will behave and produce the plume rise needed to reach an elevation with the desired wind conditions.

The $PM_{2.5}$ concentrations predicted by ClearSky are one of the major weaknesses of the model. The model was able to represent the relative strength of the sources, in that, as the amount of smoke released (acres burned) increases, the predicted $PM_{2.5}$ concentrations also increase. New emission studies for bluegrass fields have calculated emission factors much higher than the factors used by ClearSky. The physical parameters used to describe the plume rise in the model are also the subject of further investigation. Other observed behavior such as surface winds peeling smoke off the main plume and contributing to elevated smoke concentrations on the surface are difficult phenomenon to replicate with the model. The effect of terrain features such as large water bodies is another weakness of the model. Currently, the model grid resolution (4 km) is still fairly coarse and does not adequately characterize the subsidence effect of water bodies, such as Pend Oreille Lake and Coeur d'Alene Lake, on the smoke plumes as they move over the lakes.

The ClearSky model runs offer the field coordinators predicted outcomes of planned burn activity based on estimated plume rise characteristics, fuel consumption rates, and other physical parameters used in the modeling analysis. Based on the results of the 2003 season, field coordinators should use the ClearSky model to evaluate the direction of the predicted plume movements in the burn decision process. More work is needed to improve the absolute $PM_{2.5}$ concentrations predicted by the model before it can be used to make burn decisions.

Other Meteorological Data – Wind Roses

As discussed earlier, DEQ operates 10-meter meteorological towers on the Rathdrum Prairie and in Sandpoint that record wind direction and wind speed continuously. Data from these sites were processed into wind roses to provide an evaluation of the surface meteorological conditions on the burn days and for other averaging periods during the burn season. The complete set of wind roses prepared for this report is found in Appendix B. The wind roses provide a visual tool for evaluating the wind conditions for various time intervals. The Rathdrum Prairie wind roses show the surface wind conditions where the burning occurs and the Sandpoint wind roses illustrate the conditions at a possible receptor downwind from the burning.

Wind roses were prepared for the whole year (all hours - 2003 data), for the burn season (all hours – August, September and October 2003), for the burn season during the burn window (0900 to 1700 hrs PST), and for individual burn days during the burn window (0900 to 1700 hrs PST). Data from the Rathdrum site was unavailable to produce a wind rose for the August 6 burn day. An average wind rose for all the Rathdrum burn days was also produced.

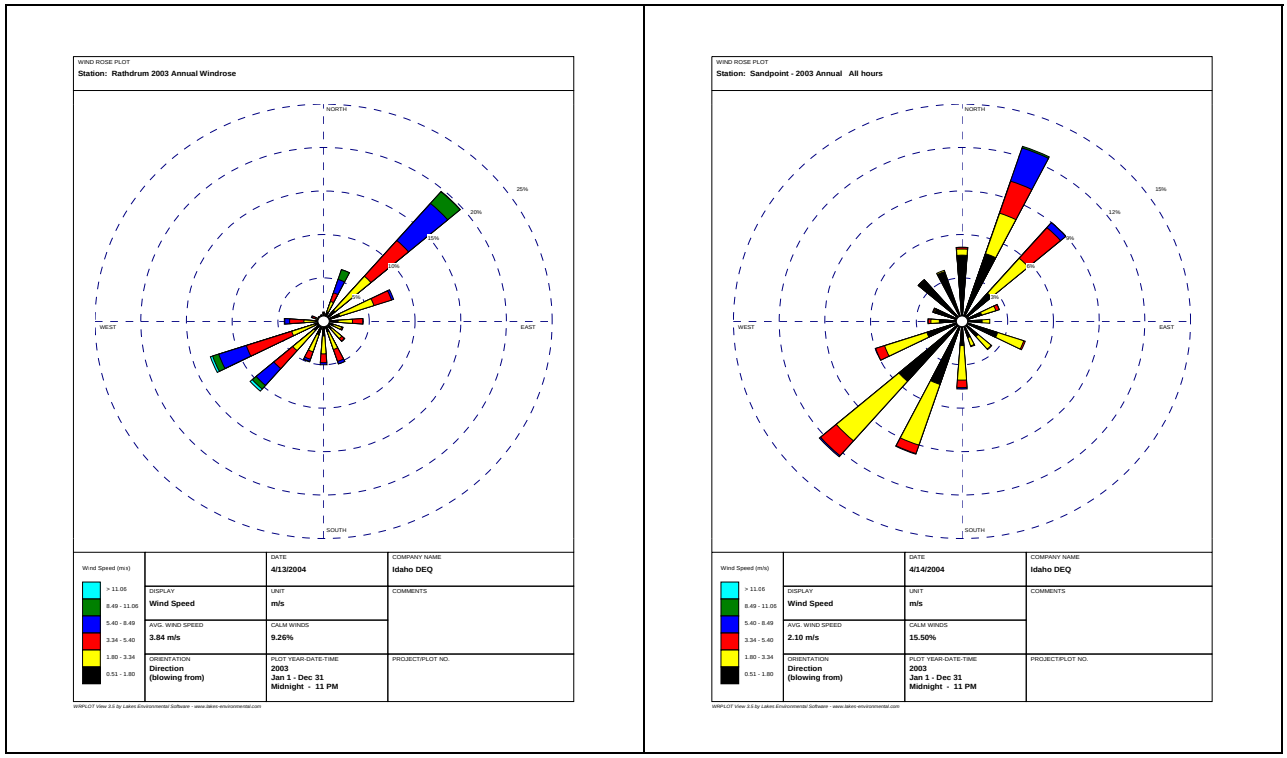


Figure 10. Annual Wind Roses for Rathdrum and Sandpoint Meteorological sites for 2003.

The wind roses show that wind strength and wind direction do vary between the two sites. In each of the time periods evaluated, the Rathdrum site had higher average wind speeds than the Sandpoint site. For the entire calendar year, the annual average wind speed at Rathdrum was 8.6 mph versus 4.7 mph for Sandpoint. Figure 10 shows the annual wind roses for the Rathdrum and Sandpoint metereological sites. The Sandpoint site experienced southeast winds more frequently than the Rathdrum site while both sites had winds from the southwest and northeast.

For six burn days that data was available from the Rathdrum site, five days showed 85 to 100 percent of the winds in the southwest quadrant during the burn window hours (0900 to 1700 hrs PST). On the August 25 burn day, the surface winds were more variable with winds from the northwest and southeast. Also, the average wind speed on the 25th was lower than the other five burn days. Average wind speeds during the burn window ranged from 4.3 mph to 13.3 mph. The prescription for the Rathdrum Prairie identifies surface winds not to exceed 10 mph for normal conditions and gusts not to exceed 15 mph for special conditions. On days that the average wind speed for an 8-hour period is greater than 10 mph indicates that surface winds may be exceeding the prescription criteria during that period. Higher surface winds could contribute to smoke peeling off from the vertical column of the plume or the plume angling towards the surface under extreme conditions. In either case, high surface winds may be resulting in more smoke in the surface layer than desired.

On August 19, when growers on the Rathdrum Prairie burned 1,613 acres, the Rathdrum wind rose shows strong winds (12 – 19 mph) from the southwest quadrant with approximately 50% of the winds from a single direction (250°) for the duration of the burn window. The Sandpoint wind rose for the same day and time also showed a similar wind pattern with lower wind speeds and more frequent winds from the southeast, see Figure 11.

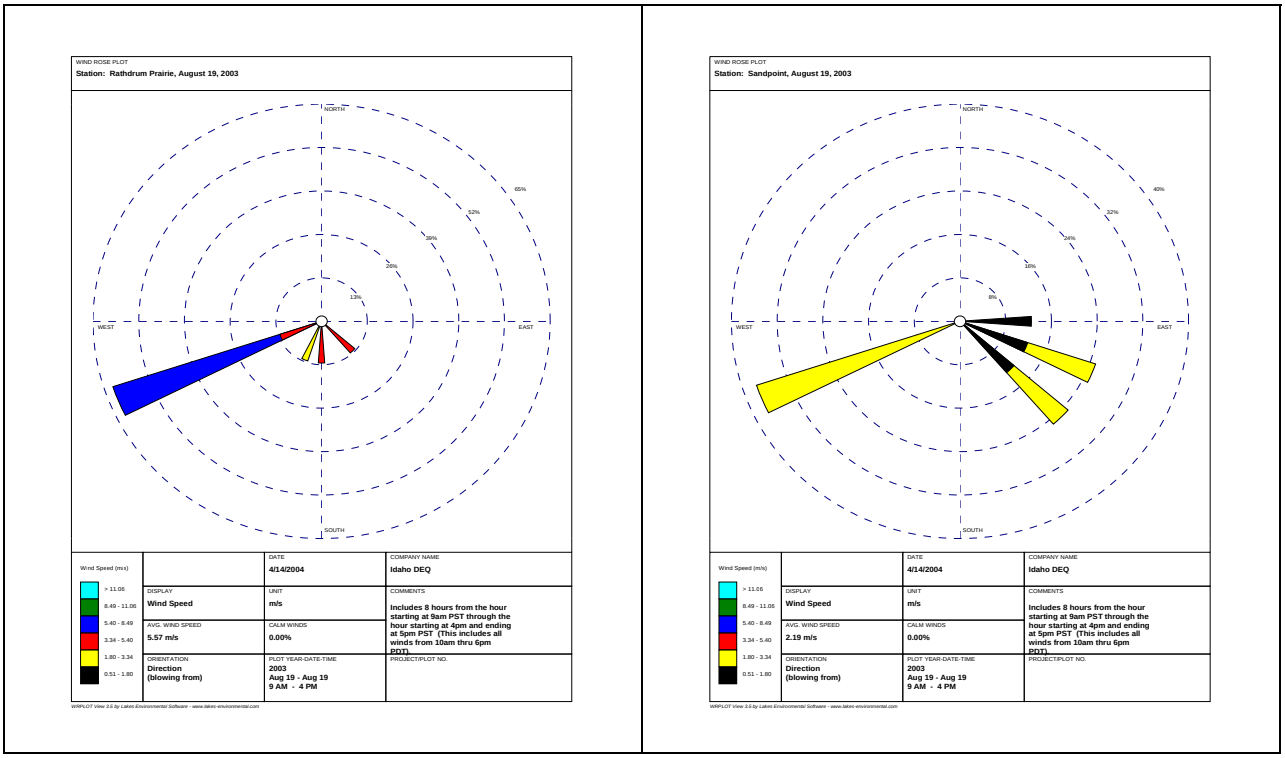


Figure 11. Wind roses for Rathdrum and Sandpoint for August 19, 2003 for the hours from 10 to 18 PDT.

Rathdrum Prairie Airshed Summary

The field coordinators on the Rathdrum Prairie have one of the most challenging smoke management jobs in the statewide program. The grass fields located on the Prairie are nearly surrounded with urbanized cities and growing rural residential communities. The smoke manager's ability to predict how smoke will move from the fields and disperse quickly with minimal impact to the public is very difficult. One small change in the weather or a field condition, e.g. fuel moisture, can result in an undesirable smoke impact to a downwind area.

During the 2003, the Rathdrum Prairie field coordinator was one of the most experienced smoke coordinators in the state. This experience combined with growers skilled in field burning practices and smoke management makes for a good working relationship on the ground. The Rathdrum Prairie airshed has the one of the most extensive set of technical tools available to support the program. As discussed in this report, this toolbox includes upper air measurements with pibals, forecast support from a contract meteorologist, ClearSky modeling runs, direct access to an extensive downwind monitoring network, and a field office centrally located on the prairie for on-the-ground observations and coordination. Even with all these tools, the program was unable to completely avoid downwind smoke impacts from occurring.

The combination of experienced managers and extensive technical support allows the SMP to track numerous environmental parameters that go into making a burn decision. The smoke managers must find a balance of environmental parameters for good smoke dispersion, plume rise and fire safety with a limited amount of time each day for practical and functional coordination with the growers. The coordinators must also continue to improve their technical skills, stay current with emerging technology, and incorporate new information into the decision making process.

Recommendations for the 2004 Season include the following;

- Identify and adopt a 24-hour $PM_{2.5}$ concentration that triggers a no-burn decision. DEQ recommends a value between 30 and 40 $\mu g/m^3$.

- Develop techniques for field coordinators to use pibal data to validate MM5 upper air forecast products, i.e. 850mb winds.

- Continue the application of the ClearSky model for the Rathdrum airshed and support refinement of plume rise and other modeling parameters to improve performance of the model.

- Closely monitor surface winds on burn days to reduce wind induced smoke impacts.

## AIRSHED DISCUSSION -- Boundary County

### Overview

The Kootenai River Valley is the major agricultural area in Boundary County with rich farmland along the flat river bottoms and adjacent benches. In Idaho, the Kootenai River runs from east to west as it passes through the city of Bonners Ferry and then turns to the north/northwest as it meanders into British Columbia, Canada. As the crow flies, the valley runs for approximately 25 miles from one end to the other.

The Selkirk Range is located on the west side and creates a dramatic valley boundary, rising 3000 ft. above the valley floor within one mile from the western edge of the valley. The mountain peaks top out at 6,000 to 6,800 ft. throughout the north-south oriented range. The eastern boundary is less dramatic with ridge tops at 4000 to 5000 ft. elevations. These geographic features have a strong influence on the local weather patterns and play a significant role in the agricultural smoke management program.

In 2003, the second year of the implementing the statewide registration program, Boundary County growers registered 11,032 acres for burning. In 2002, growers had registered 8,904 acres for burning. During the 2003 season, growers burned 7,561 acres on 18 burn days in Boundary County. Acres burned per day ranged from a low of 7 to 10 acres for test burns to a high of 1,574 acres. The current airshed prescription for Boundary County established limits of 2,400 acres for a burn day and 600 acres for a conditional day.

Table 7. Summary of Boundary County Burn Days, $PM_{2.5}$ Concentrations and Hotline Calls.

| Date | Acres Approved/ Acres Burned | Location Of Field Relative To The KTOI Monitoring Site | Maximum 1-hour $PM_{2.5}$ Conc. ($\mu g/m^3$) | Hour Ending Time Period (PST) | Complaints Received by Hotline |
|---|---|---|---|---|---|
| 8/11/03 | 300/120 | North of Copeland | 7 | 10 am | 30 |
| 8/12/03 | 200/10 | North of Copeland | 7 | 12 am | 39 |
| 8/13/03 | 115/35 | North of Copeland | 7 | 1 am | 8 |
| 8/19/03 | 300/80 | North of Copeland | 14 | 12 am | 0 |
| 8/25/03 | 500/200 | East side, N. of River | 11 | 10 pm | 2 |
| 8/26/03 | 1500/220 | North of Copeland | 27 | 9 pm | 11 |
| 8/27/03 | 1500/7 | No burning done | 21 | 1 am | 0 |
| 8/29/03 | 600/301 | North of Copeland | 41 | 1 pm | 0 |
| 9/3/03 | 1900/1524 | North of Copeland | 47 | 2 pm | 6 |
| 9/5/03 | 1700/1573 | North and at Copeland | 33 | 1 am | 0 |
| 9/10/03 | 1000/358 | North of Reservation | 8 | 11 am | 1 |
| 9/11/03 | 1000/304 | East and also North | 4 | 11 pm | 0 |
| 9/16/03 | 1000/396 | East and also North | 6 | 7 am | 0 |
| 9/18/03 | 600/379 | South of KNWR* | 4 | 9 pm | 0 |
| 9/22/03 | 1700/1400 | North of Reservation and also near border with BC | 4 | 3 am | 4 |
| 9/25/03 | 50/50 | North of Copeland | 8 | 7 pm | 0 |
| 9/29/03 | 600/554 | West side, N. of KNWR | 12 | 6 pm | 0 |

Burn Day Evaluations

The field coordinator in Boundary County has fewer technical resources available for making a burn decision as compared to the Rathdrum Prairie. No upper air wind measurements were collected and the ClearSky model was not configured in 2003 to include Boundary County. The field coordinator started releasing balloons for visual observations during the later part of the season but did not have the equipment available to make pibal measurements.

The University of Washington MM5 website provided forecast products that include Boundary County in the 4 km and 12 km domains, but little work has been done to reconcile the forecast products with actual weather conditions in this airshed. The field coordinator found the forecast products, especially the Ventilation Indexes that predict surface winds (20 meters), very unreliable. The simple balloon release and observation helped provide more accurate information on the direction of upper air winds that the weather models had difficulty predicting.

An assessment of the burn day decisions was more difficult in this airshed because of the limited air quality data available as compared to the Rathdrum Prairie. The Kootenai Tribe of Idaho operates an air quality monitoring site on the reservation located northwest of the City of Bonners Ferry. As described earlier in this report, the Tribal air quality site collects $PM_{2.5}$ data and surface weather data with continuous sampling methods. See Tables 3 and 4. The air quality data from the Tribal site provides limited resolution on the $PM_{2.5}$ concentrations that occur in the Kootenai River Valley. Additional monitoring sites are needed to better characterize the spatial variability that may exist in $PM_{2.5}$ concentrations especially when agricultural burning, wildfires and slash burning are contributing smoke to the airshed.

Figures 12 and 13 show the one-hour and the 'rolling' 24-hour average $PM_{2.5}$ concentrations measured by the nephelometer at the Kootenai Tribe site for August and September 2003. As mentioned earlier, the nephelometer provides an indirect measure of particulate concentrations by using a light scattering measurement technique. The nephelometer scattering data is correlated with a $PM_{2.5}$ reference method to generate $PM_{2.5}$ concentrations.

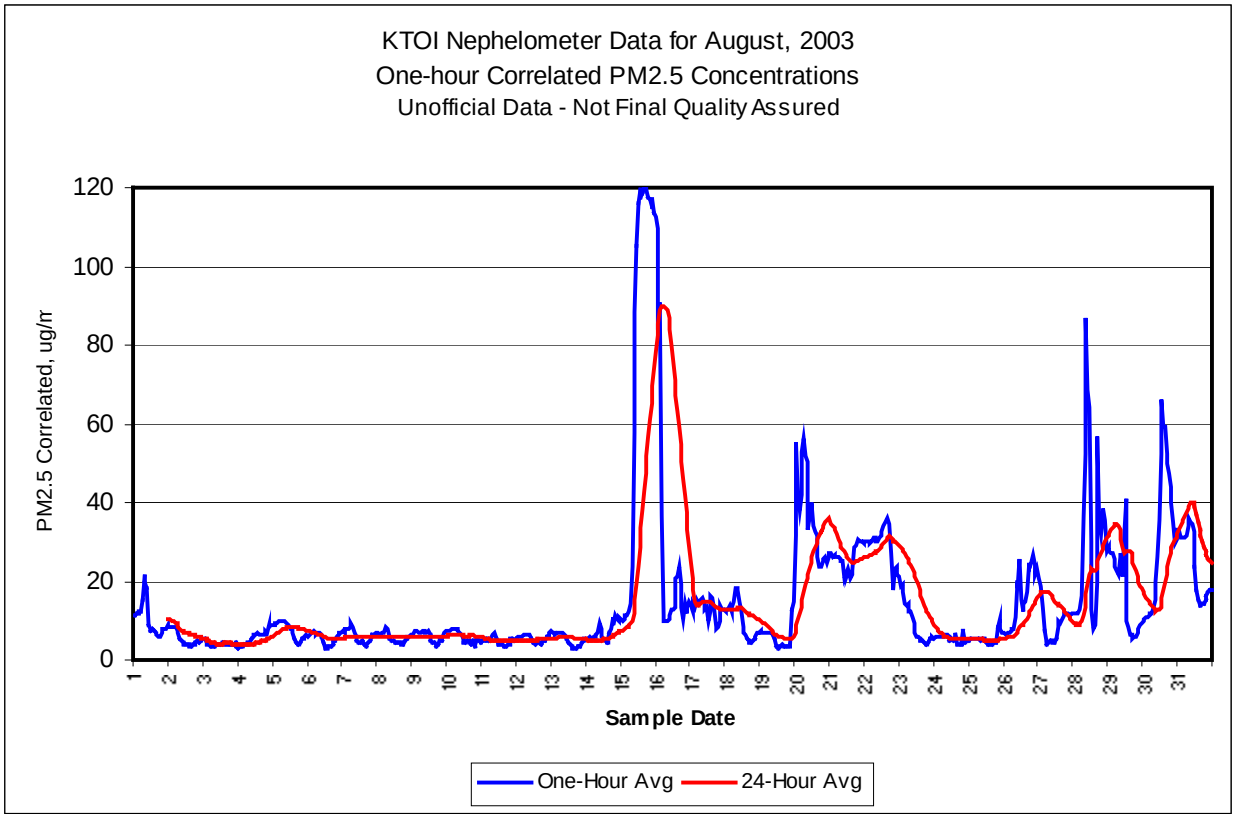


Figure 12. $PM_{2.5}$ Concentrations for August 2003 from the Kootenai Tribe site.

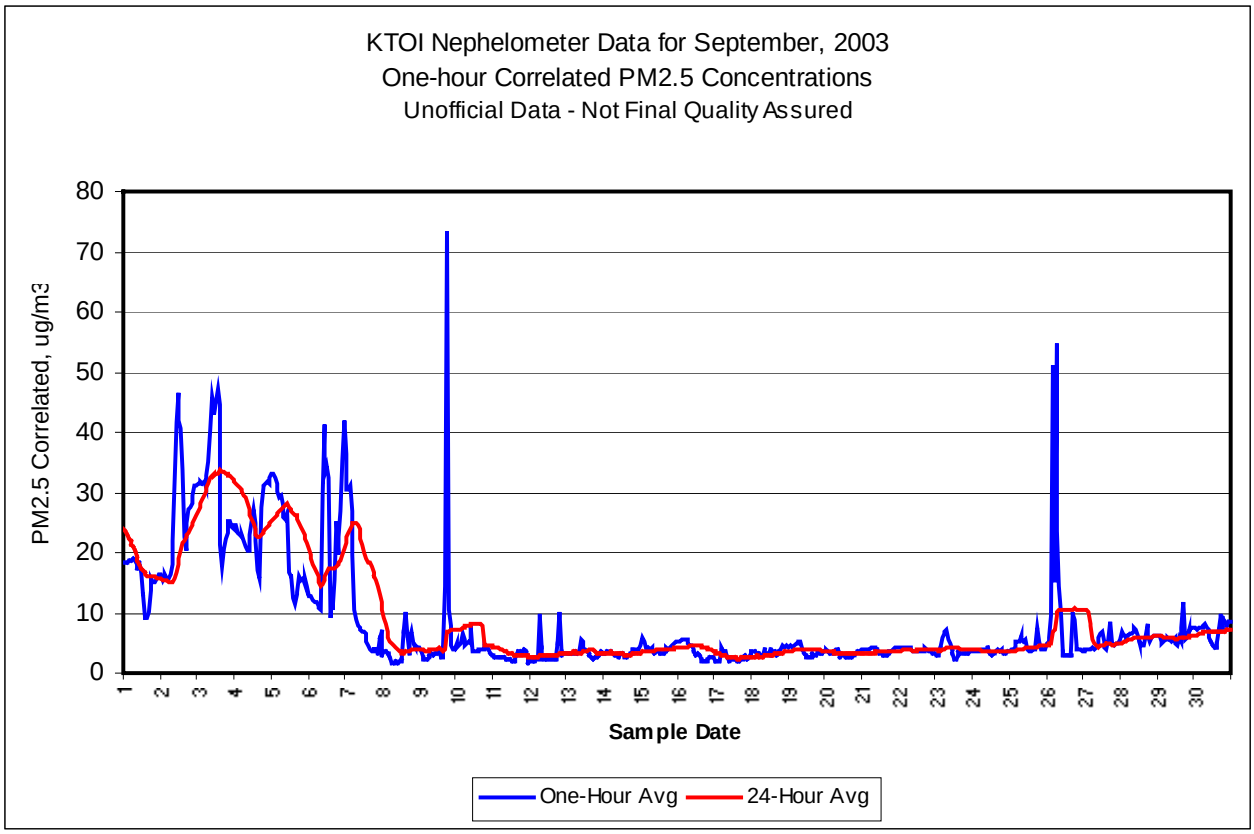


Figure 13. $PM_{2.5}$ Concentrations for September 2003 from the Kootenai Tribe site

Wildfire Smoke Impacts

The $PM_{2.5}$ data shows that some significant smoke impacts did occur in the Kootenai River valley but based on burn records and observations by the field coordinator, the Kootenai Tribe, and DEQ staff, the source of the smoke was likely from local and regional wildfires, not agricultural burning. On August 15, smoke migrated into the valley from wildfires outside of Boundary County and caused a dramatic increase in $PM_{2.5}$ concentrations. This effect was also recorded at the monitoring sites in Bonner County and to a lesser degree, in Kootenai County. Based on the nephelometer data from the Kootenai Tribe, the 24-hour $PM_{2.5}$ standard was exceeded on August 15 with a 24-hour average of 74 $\mu g/m^3$. The $PM_{2.5}$ NAAQS is 65 $\mu g/m^3$ for the 24-hour standard. The maximum rolling 24-hour average was 90 $\mu g/m^3$ recorded the following morning at 0500 PST. $PM_{2.5}$ concentrations between 65.5 and 150.4 $\mu g/m^3$ fall in the Unhealthy AQI category. The peak one-hour $PM_{2.5}$ concentration was 120 $\mu g/m^3$ recorded at 1800 PST on August 15 which is in the Unhealthy for Sensitive Groups AQI category.

The Myrtle Creek wildfire was a major local wildfire. The wildfire burned just west of Bonners Ferry and the Tribal monitoring site on September 2, 2003 and grew to 3,800 acres during the first week of September. This local wildfire generated smoke impacts that were recorded by the Tribal site. Air quality levels were in the Moderate AQI category for approximately one week, from August 30 to September 7. The maximum 24-hour $PM_{2.5}$ concentration recorded during this time period was 34 $\mu g/m^3$ (September 3 at 1500 PST). Hourly $PM_{2.5}$ concentrations climbed to 47 $\mu g/m^3$ at 1400 hrs PST before dropping back down into the twenties. The average background $PM_{2.5}$ levels are below 10 $\mu g/m^3$ when no fires are present.

Wildfire suppression teams were coordinating with the ISDA field coordinator during the Myrtle Creek fire. Throughout the week, growers burned approximately 3,100 acres in the Kootenai River Valley. Figure 13 shows that the hourly $PM_{2.5}$ concentrations were increasing throughout the morning on September 3rd when 1,900 acres were approved for burning. Growers in the valley burned approximately 1,500 acres. The dispersion forecast on this day called for moderate to good ventilation conditions during the course of the burn window (10 am to 4 pm). Due to the rising $PM_{2.5}$ levels, a more conservative burn call may have been warranted. This situation revealed one the problems that occurred in this airshed.

Access to the AQ data was one of the technical problems the smoke managers encountered during the 2003 season in Boundary County. Due to problems with the phone line connected to the air quality monitoring site, remote access to the monitoring data was very limited on a day to day basis. Poor telephone line transmission quality constantly interrupted data access and often prevented remote access altogether. The Tribal AQ staff had the best access to the data but staffing limitations affected their ability to continually monitor and track changing trends. The Tribe is working to improve remote access to air quality data for DEQ, ISDA and the public. In addition to the quality of the telephone line transmission, the Boundary County field coordinator had to spend the majority of the day in the field and this further hampered access to air quality data.

Wildfire source impacts were apparently more serious in the Creston Valley in British Columbia during the 2003field burning season. Agricultural burning in Boundary County further angered Creston citizens who were already dealing with a smoke filled airshed. A large number of

complaints received by the ISDA hotline were from Canadian citizens in the Creston Valley area. Smoke management and air quality staff on both sides of the border were exchanging data and information. An air quality monitoring site with a $PM_{10}$ TEOM is located in Creston, BC and the data is posted to a website on a continuous basis (http:\\wlapwww.gov.bc.ca:8000/pls/aqiis/air.summary). Unofficial $PM_{10}$ data from the Creston site showed a maximum $PM_{10}$ concentration of 170 $\mu g/m^3$ recorded at 1500 hrs PST on September 3, 2003.

Weather Forecasts

In Boundary County, the smoke management program had to rely on weather forecast products derived from the National Weather Service, the daily forecasts and burn recommendations from SMP contract meteorological service and the MM5 forecast products from the University of Washington. Actual data was limited to surface observations made by at the Kootenai Tribe site and by other surface meteorological stations such as the USFS RAWS sites. Long-time residents of the Kootenai River Valley have noted that weather forecasts from the Spokane or Missoula NWS offices are not very reliable for this valley.

The ClearSky modeling program did not include Boundary County for the 2003 season so there were no plume forecasts available to review. Also, the field coordinator did not have any upper air measurements, pibal or sodar data, for the Kootenai River Valley. Predicting the upper layer transport winds was limited to the MM5 model runs and the NWS products. Later in the season, the field coordinator started releasing weather balloons and visually tracking them through the atmosphere. This provided a crude but effective observation of the upper layer transport winds.

A post-season analysis of the 10-meter wind data from the Kootenai Tribe site was conducted by processing the data into wind roses. Data from eight days during the burn season was processed using the Lakes Environmental WRPLOT View software to produce daily wind roses for the burn window 9 a.m. to 5 p.m. PST. Seven of the eight days analyzed were burn days. Other seasonal and annual average wind roses were also produced from the 2003 data set using this same software. The complete set of wind roses for Boundary County is found in Appendix C.

Table 8. Average Wind Speeds from Wind Rose Analysis of Kootenai Tribe Data

| Date | Aug 11 | Aug 12 | **Aug 15**[1] | Aug 25 | Aug 26 | Sept 3 | Sept 5 | Sept 22 |
|---|---|---|---|---|---|---|---|---|
| Wind Speed, mph | 11.86 | 7.52 | 4.92 | 8.97 | 10.22 | 5.64 | 9.84 | 12.2 |

[1]August 15 was an approved burn day but no acreage was burned.

The average wind speeds presented in Table 8 generally meet the prescription criteria for Boundary County. Further analysis of the peak gusts during days when the average wind speed is greater than 10 mph, e.g. August 11 and 26, and September 22, would reveal if these burn days met the prescription criteria for surface wind speed.

The wind rose analysis for all of 2003 data shows that the dominant winds recorded at the Kootenai Tribe site are from the south. This same trend holds true for the analysis of the 2003 field burning season for the months of August through October. These trends are illustrated in the Figure 14 below.

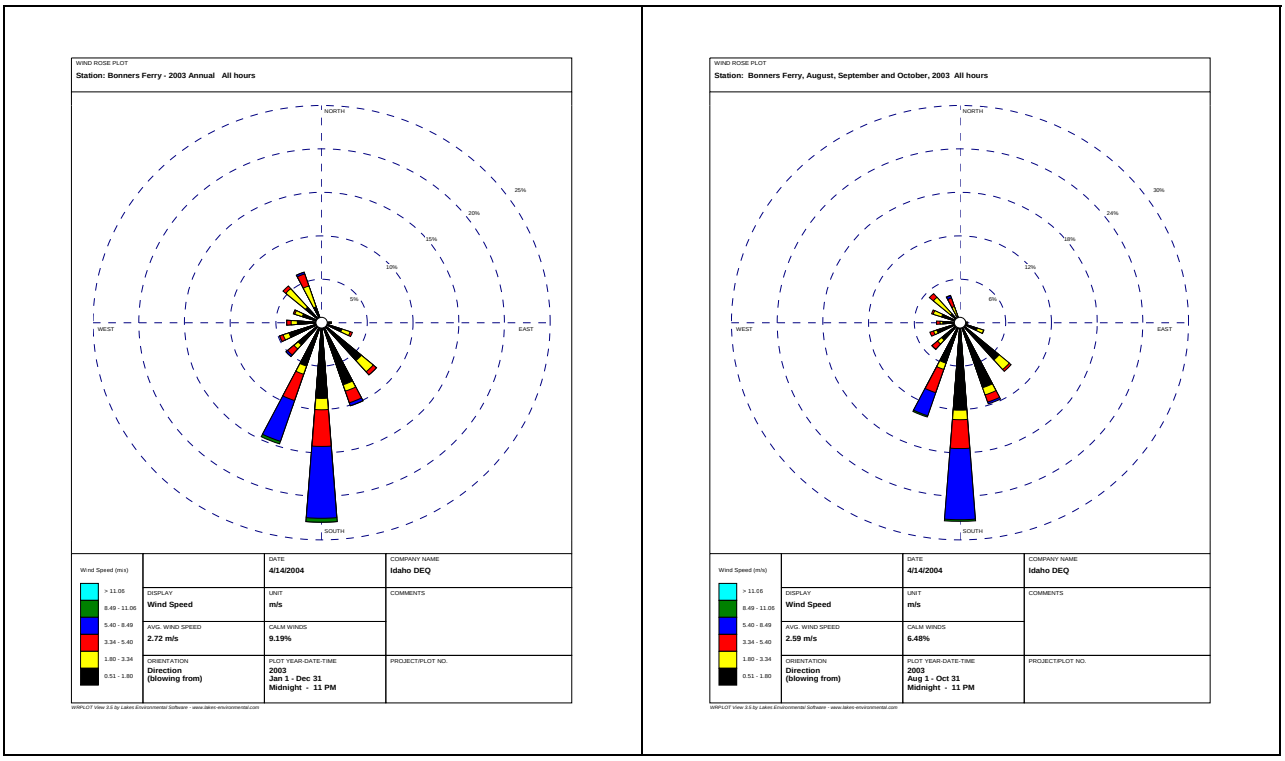


Figure 14. Annual and Seasonal Wind Roses from Kootenai Tribe wind data for 2003.

The wind roses for the individual burn days generally showed this same type of trend with a strong south wind influence. August 12 and September 3 were exceptions as shown in Figure 15 below. The wind rose for August 12 showed a strong west wind component for approximately 35% of the 8-hour burn window. The September 3 wind rose showed the influence of a west/northwest wind for approximately 25% of the burn window. No burning was accomplished on August 15 but the wind rose for this day did not show any winds from the south. All of the winds during the burn window on August 15 were from the northwest quadrant.

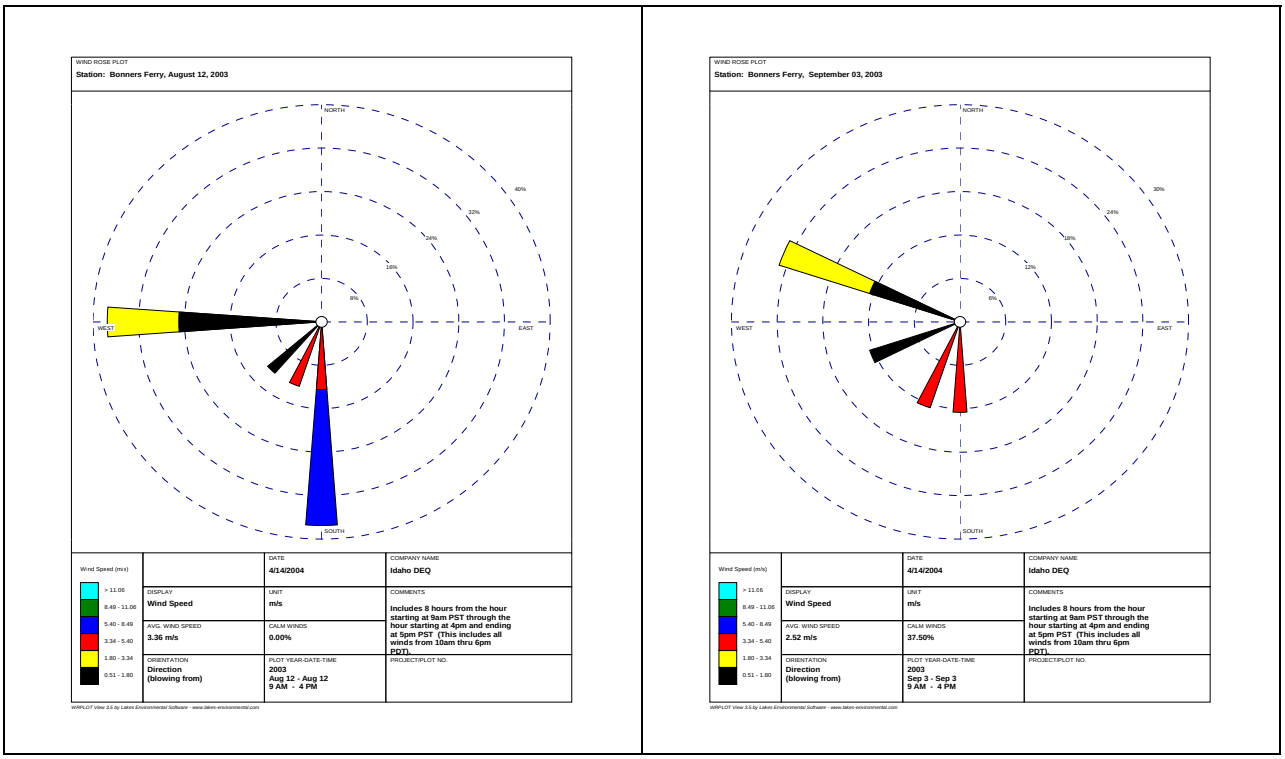


Figure 15. Wind roses from Kootenai Tribe data for August 12 and September 3, 2003 for the hours from 10 to 18 PDT.

## Boundary County Airshed Summary

The CRD smoke management program in Boundary County is still maturing. The growers have run an informal program for several years prior to the development of the ISDA statewide program. That local experience and knowledge must now be transferred or acquired by the ISDA program. The technical tools that are needed to support the program are also still in the growth phase. A partnership with the Kootenai Tribe has provided air quality and weather data representing a portion of the Kootenai River Valley. Other partnerships must be developed to further enhance environmental monitoring for this airshed.

Formal agreements with the British Columbia Ministry of Water, Land and Air Protection (BC WLAP) may provide additional information from the Creston Valley area. BC WLAP is planning to deploy additional air quality and meteorological monitoring sites in the Creston Valley. Local meteorological forecast information may also be available from WLAP. Agreements with one of the large commercial farms may provide additional data for surface winds at the north end of the valley on the Idaho side of the border.

Improved access to the air quality site operated by the Kootenai Tribe will increase the awareness of elevated $PM_{2.5}$ concentrations. The Kootenai Tribe has committed to providing additional resources both with personnel and equipment to improve data tracking for the 2004 field burning season. Also, the ClearSky project is planning to expand coverage of the plume forecasting program to Boundary County for the 2004 season. ISDA may also have additional equipment to evaluate upper air transport winds with pibal observations or other techniques.

# Appendices

## Appendix A.

ClearSky Products for Eight Rathdrum Prairie Burn Days with Hourly $PM_{2.5}$ Data

ClearSky Products for Select No-burn Days

## Appendix B

2003 Wind Roses for Rathdrum and Sandpoint Meteorological Stations

## Appendix C

2003 Wind Roses for Kootenai Tribe Meteorological Station in Boundary County